

**The nature and remediation of spatial problems associated
with interpreting diagrams of biological sections**

VOLUME II: THE INSTRUCTIONAL PACKAGES

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Cape Town, March 1995

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SCHEDULE OF LESSONS

This recommended "time planner" has been included so that you have some idea of how much time you will need for each of the lessons.

One of the aims of this package is to ensure that teachers do not have to deviate more than is necessary from their normal Std 8 lessons on the structure and function of cells. However, teachers are asked to include the following introductory exercises when they teach the section on the cell. **Please emphasis strongly (to the pupils) that this is NOT extra work irrelevant to the syllabus.** These lessons are to assist them to develop skills which are absolutely essential for them to succeed as biology scholars.

Thereafter the teaching is left to the teacher. However, teachers are asked to incorporate the worksheets on cell organelles, and other relevant exercises, into those lessons in which they deal with those organelles.

As teachers will realise, the active involvement of pupils in the learning task inevitably means that more time is spent teaching that section of work. Thus some of the tasks are for pupils to complete at home. **Teachers are asked to ensure that pupils do complete these exercises, and that they have some sort of follow-up in class, even if it is merely a class display of drawings which have been done.**

LESSON 1:

- * The importance of the spatial skills (tested during the pre-tests) in biology.
- * Feedback on pupils diagnostic test results.
- * Remediation of spatial skills
- * Pictorial depth cues and interpreting stereograms

LESSON 2:

- * The concept of sections (geometric shapes)

LESSON 3:

- * The skill of accurate observation and drawing
- * Biological sections

LESSON 4:

- * Revision of the cell concept
- * Visualizing cell sizes

LESSON 5:

- * Revision of the cell as a 3-D structure
- * Visualizing the sizes of organelles

FURTHER LESSONS:

A series of exercises on the structure and function of organelles has been provided for inclusion in the teacher's lessons, together with activities which are designed to help the pupils to visualize cells and organelles in 3-D.

EVALUATING THE PACKAGE

I would greatly appreciate it if you would take the time to comment on the suggestions made in this package, and on how the pupils responded to the lessons. Your comments will be used to improve the package for possible use, at a later date, in South African classrooms.

You are asked to comment in two ways:

1. Please complete the pink form which you will find at the end of the materials for each lesson. This will provide me with information about HOW the various tasks were approached and checked, and it will also alert me to any problems which might require attention.
2. Please use a red pen to write comments directly onto the pages in this teacher's file. Copies of all the pupils' exercises have been included for this purpose. These files will be returned to me, and I will give you a replacement copy once I have made any modifications. Please indicate mistakes, inconsistencies, unclear explanations, unclear diagrams or illegible print, requests for more details, and any suggestions you have for improving the package and making it more helpful to Std 8 biology teachers.

Your assistance in testing the ideas and materials in this package, and in taking the time to comment on them, is greatly appreciated.

LESSON 1: **(Spatial skills in biology)**

Recommended time

Two single periods **OR** one double period.

Purpose of the lesson

1. To explain to the pupils that researchers have found that many biology scholars have problems with interpreting (understanding) what the diagrams used in biology textbooks represent (i.e. what these structures would look like in real life).
2. To explain the importance of spatial ability in biology, especially when dealing with biological sections.
3. To interest pupils in identifying and remediating their spatial weaknesses.
4. To teach the pupils about the use of pictorial depth cues.

Requirements for lesson

1. Results from diagnostic tests already written
2. Overhead transparencies:
 - 3-D diagram of root
 - 3-D diagram of leaf
 - 3-D diagram of anther
 - stereogram of balloon / ball
 - stereogram of cubic box
 - depth cues used by artists
 - stereogram of man in park / railway line
 - stereogram of chair
3. Worksheets for pupils: (1 per pupil)
 - * Remedial exercises
 - hidden figures
 - rotate-and-flip
 - mental rotation in 3-D
 - paper-folding
 - view-from-the-top
 - mental jig-saw puzzle (find the missing shape)
 - make-the-cardboard-model
 - sawing-through-the-shape
 - * Can you interpret stereograms?
4. Answer sheets for teacher:
 - * Remedial exercises for the eight exercises listed above (to be used at the start of the next lesson)
 - * Can you interpret stereograms?
5. Balloon or large ball, and a cubic box or piece of wood

Points to be made to the pupils during the lesson

First half of lesson:

1. Explain to the pupils that the purpose of the lesson is to teach them to interpret 2-D pictures as 3-D structures, by teaching them about artists' depth cues.
2. Use the three 3-D OHTs of root, anther and leaf to show pupils the types of diagrams which they need to be able to understand (i.e. to imagine in 3-D).
 - * Explain that researchers have found that when pupils look at such 3-D diagrams (stereograms) many of them can't understand (imagine) what they would look like in 3-D in real life.
 - * Because diagrams are often used in biology teaching, pupils need to develop their ability to picture in their minds what these structures would look like in 3-D.
3. Allow the pupils to work in small groups (four pupils per group).
 - * Show them a blown up balloon (or a large ball), and ask them to try to draw it so that their drawing looks 3-D.
 - * Ask them to compare drawings with others in their group, and decide which one looks the most 3-D.
 - * Ask them what gives this particular diagram a 3-D effect.
 - * Use the OHT of the balloon (ball) to show the effect of shading where dark parts usually represent areas further from the viewer, and light parts areas closer to the viewer.
 - * List the "effects" on the chalkboard (e.g. **shading**, **highlighting** etc.)
4. * Show the pupils the box (cube) and again ask them to draw it so it looks 3-D.
 - * Again allow them to compare drawings and DISCUSS which looks the most 3-D and why.
 - * Use the OHT of the box to show the methods used by the artist to make the box look 3-D (**shading**, **angle distortion** and **fore-shortening of lines**). (See "teachers' notes").
5. * Explain that artists use these "depth cues" if they want to make diagrams appear 3-D. "Depth cues" are devices which, although drawn on paper which is only 2-D, give the appearance of depth and 3-D.
 - * Point out that the viewer must understand depth cues in order to interpret a stereogram in three dimensions.
 - * Use the OHT "depth cues used by artists" to discuss the types of depth cues which artists often use (see "teachers' notes").
 - * Use the OHT of the man in the park, and the OHT of railway lines, to show the use of **size** and **convergence of lines**, and **texture**, to illustrate depth.
6. * Use the OHT of the chair to illustrate the use of **shading**, **angle distortion**, **fore-shortening of lines**, and **overlap**.

7. * Give the pupils the exercise "Can you interpret stereograms?" to complete in class. This should not take more than 10 minutes to do.
 - * Briefly go over the answers.

Second half of lesson:

8. Inform the pupils of their results from the spatial exercises conducted last week by the researcher. (The teacher will be informed of the results, and what marks are considered to be "good", "average" and "weak").
9. * Emphasise why biologists need various spatial skills (see "teachers' notes").
 - * Really try to motivate the pupils to practise and develop these skills.
10. Handout the remedial spatial exercises.
 - * Go over the reasons why biologists need each skill.
 - * Get pupils to read over hints on how to do the exercises, and then to actually do the exercises. This is best done in class, as the teacher is available to help. However the exercises can be done for homework if the teacher is short of time.
 - * Encourage ALL pupils to complete each remedial spatial exercise.

NB: Plan to give the pupils feedback on the exercises. It is suggested that answers are posted on a notice-board, and that pupils are motivated and encouraged to check on their answers, and to go to their friends or to the teacher if they need extra help.

PLEASE TRY TO MOTIVATE THE PUPILS SO THAT THEY ARE EXCITED AND CHALLENGED BY THIS WORK.

TEACHER'S NOTES

(Lesson 1)

The use of depth cues

Extensive use is made of diagrams in the teaching of biology. It is alarming to discover (from educational research) that many biology pupils faced with such diagrams are not able to "see" what they are meant to represent.

*This is a particular problem with stereograms (pictures which are drawn to represent a structure in 3-D). Teachers assume that by using stereograms they are **HELPING** pupils to see in 3-D. Research shows, however, that such diagrams are often meaningless to pupils. Some researchers suggest that this is a minor problem which can be rectified by teaching pupils to use depth cues. **Depth cues are the techniques used by artists to make their 2-D pictures appear 3-D.***

SHADING: *The use of hatching, dots, or shadows often helps to give a 3-D appearance. Many of the pupils probably already use this technique in their drawings outside the biology classroom. The exercise of getting them to try to draw the balloon (or ball) in 3-D will probably result in their use of this technique. (See OHTs).*

OVERLAPPING: *This seems so obvious as not even to require mention. Naturally any object which is in front of another will obscure it to some extent. Thus it is easy to decide which objects in a picture are nearer to or further from the viewer. (See building partially obscured by trees in the OHT on depth cues used by artists).*

DECREASING SIZE and CONVERGENCE OF PARALLEL LINES: *The further away objects are in a picture, the smaller they are drawn. Parallel lines appear to converge as they move further from the viewer.*

Thus in the OHT of the men in the park, one man is not a giant and the other a dwarf. Nor is the first tree a giant redwood, and the others newly planted saplings. All three trees are the same size (in real life), as are the two men and the telephone poles in the lower drawing.

Obviously the railway lines in the lower drawing could not really get closer together, or the train would be in real trouble. The narrowing of the tracks is merely an artistic depth cue to give the impression that the tracks are vanishing into the distance.

TEXTURE: *The same OHT also shows how artists often decrease the texture or amount of detail in a drawing as they move from the foreground to the background (see the texture of the tree trunks).*

DISTORTION OF ANGLES: *Another trick to give the appearance of depth is the distortion of angles. In the OHT of the box, all the angles are actually right-angles, yet the artist has made many of the angles obtuse and others acute. It is not that the box is really a weird shape. The distortion of angles is a depth cue to make the box appear 3-D. The same is true of the building in the OHT on depth cues. It doesn't really rise to a peak at the front.*

FORE-SHORTENING OF LINES: *In the OHT of the box, the sides (in the drawing) all appear to be different lengths. Yet we can see that the diagram represents a cube, and we know that all the sides (in real life) must be equal. The artist has shortened some of the lines to make it look as if they are further away from the viewer.*

Why biologists need a range of spatial skills

Several remedial exercises have been provided to allow the pupils to practise these spatial skills. Please emphasise the importance of these skills to successful biologists.

1. The **hidden figures exercise**: This measures the pupil's ability to keep in mind a particular mental picture, by disembedding it from its distracting surroundings.

Biologists require this skill when viewing specimens under the microscope, as it allows them to concentrate on the relevant "bits" they are examining. Pupils (and students) new to microscope work often struggle to find what it is they are looking for on a slide, and find it difficult to ignore the rest.

This skill is also needed when the teacher is showing pupils a particular structure which is only part of a larger diagram. Pupils must be able to concentrate on that structure, and to ignore the rest.

2. The **rotate-and-flip** and **find-the-missing-shape exercises**: These measure the ability to mentally manipulate visual images in two dimensions.

Biologists need this skill when viewing slides under the microscope, because the specimens are not always mounted in the expected direction. Pupils often expect to see the objects the same way up as they appear in the textbook diagram, and are put off if the orientation is different. This is a particular problem when viewing randomly mounted microscopic whole mounts.

3. The **mental rotation in 3-D exercise** and the **view-from-the-top exercise**: This measures a similar skill (mental manipulation of a mental image) but in three dimensions.

Biologists require this skill if they try to imagine what 3-D structure would look like from a different perspective (angle).

4. The **paper-folding exercise**: This tests the ability to mentally manipulate a visual image in 3-D.

This ability is of particular importance for biologists, because of the symmetrical nature of living things. They need to understand that in bilaterally symmetrical organisms, for example, the one half forms a mirror image of the other. This skill helps pupils to understand the symmetrical arrangements of parts in the whole organism.

5. The **make-a-cardboard-model exercise** and the **sawing-through-a-shape exercise**: These test not only the ability to mentally rotate a visual image, but also the ability to perform some other mental operation on the image. For example, the cardboard model exercise demands that the user mentally bends and folds the image to produce a 3-D model. In the sawing-through-a-shape exercise the user has to imagine the sawing action, the separation of the two halves, and the resulting sectional shapes.

Biologists need these skills when they are faced with 2-D pictures of biological structures, which they must imagine as 3-D wholes.

The skill is even more important when they examine a biological section, and must try to imagine the whole structure from which it was cut, and the relationship between the section and the whole. Research shows that students have particular problems in this area. They need to be able to form a mental picture of a section, if faced with a whole specimen, and they also need to be able to imagine the whole structure if they are provided with a section.

the first of these is the fact that the system is not a simple one, and that the results are not always as expected.

The second of these is the fact that the system is not a simple one, and that the results are not always as expected.

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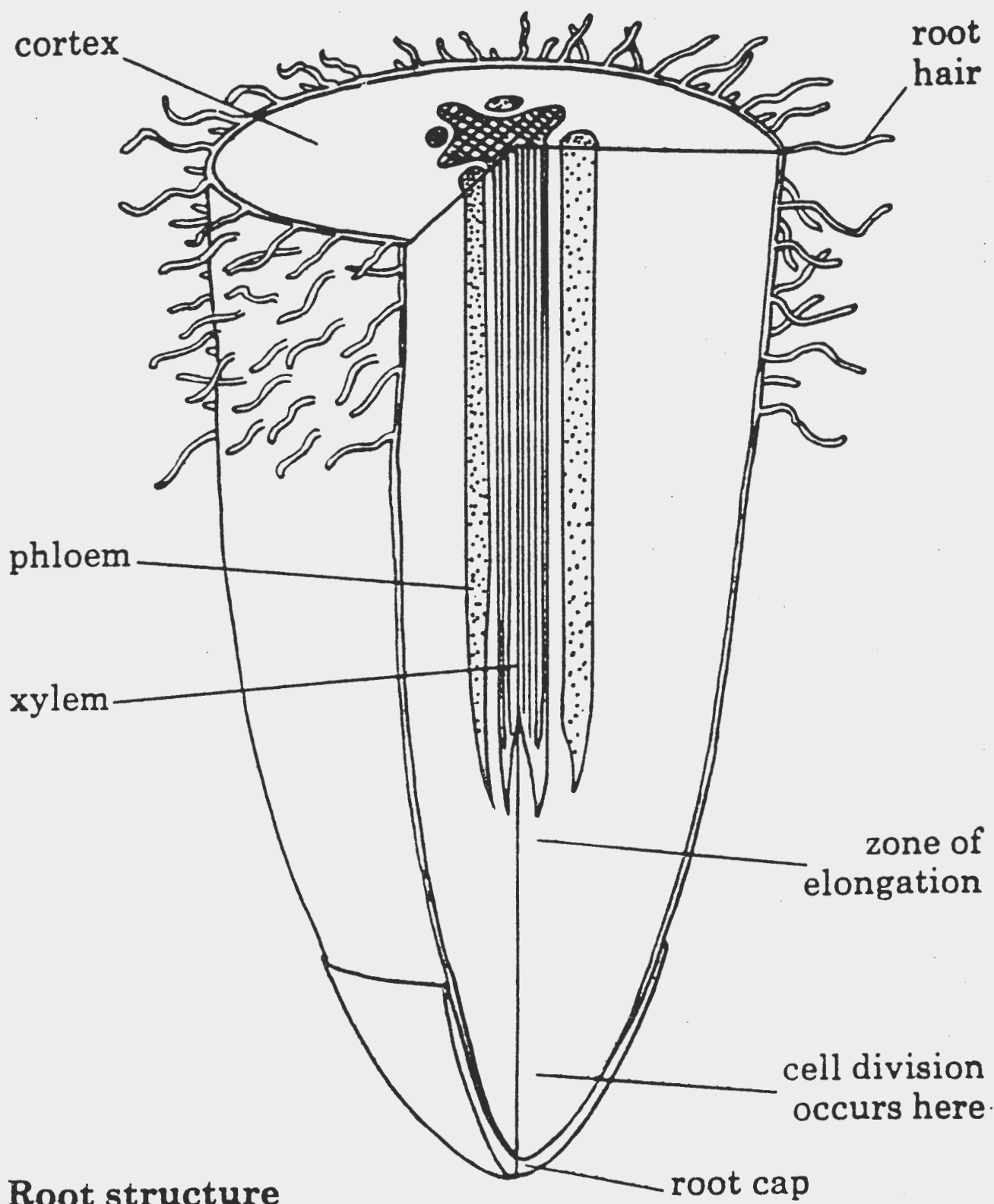
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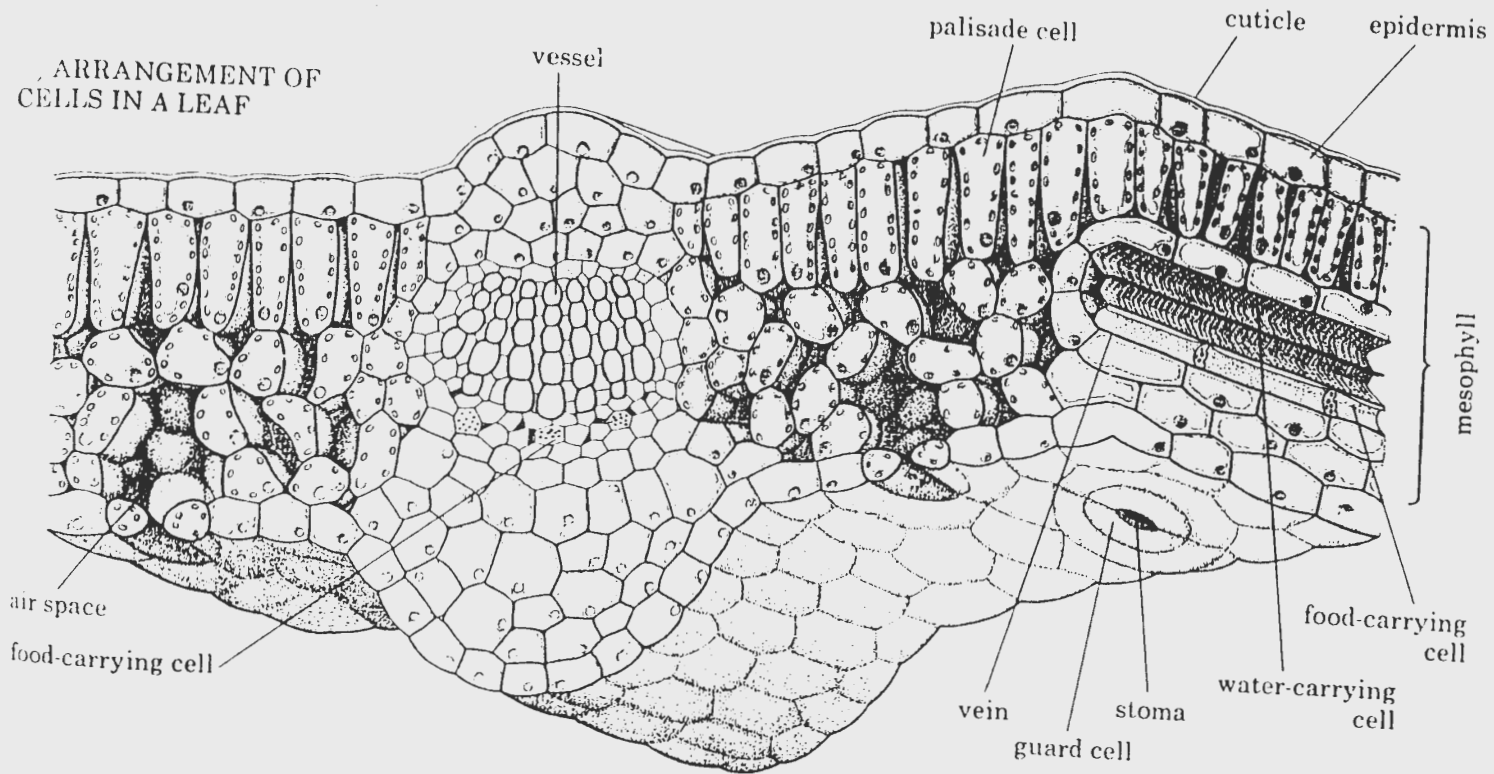
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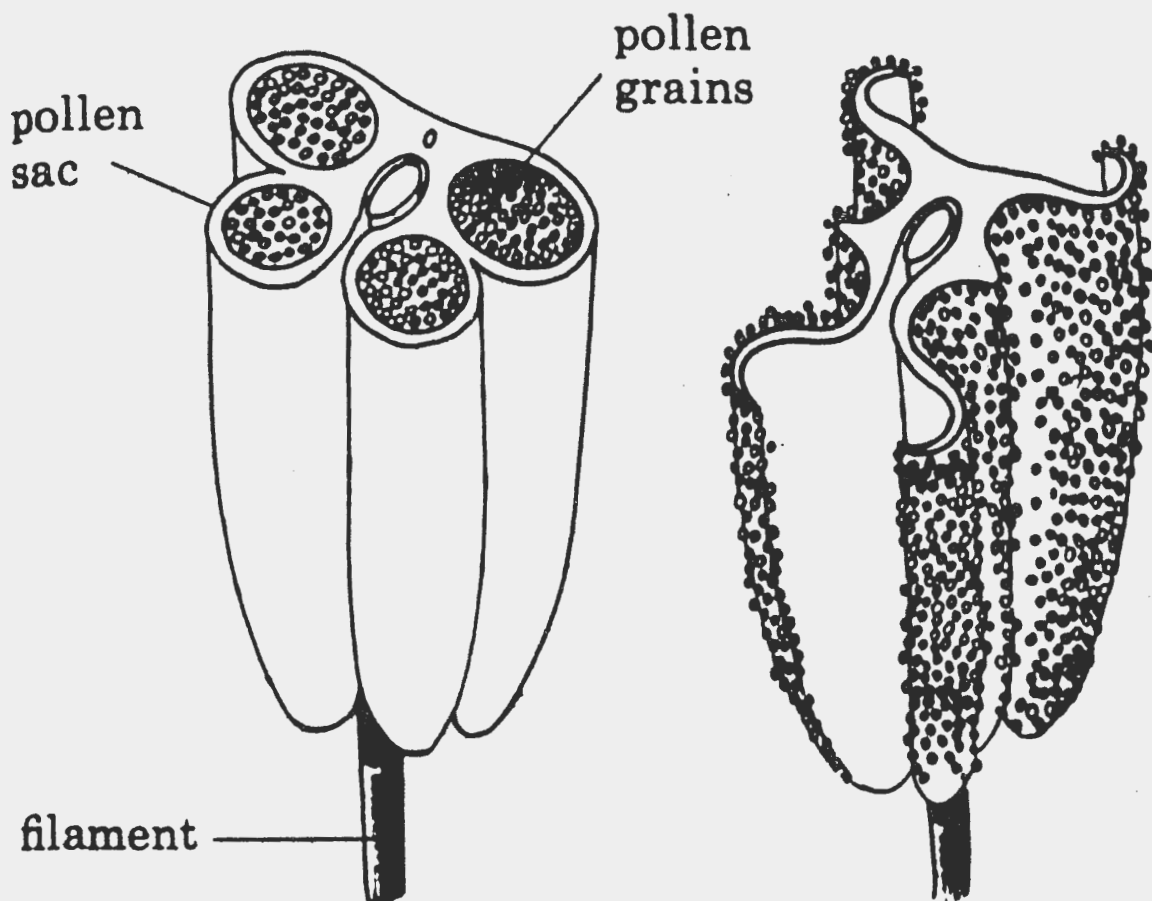
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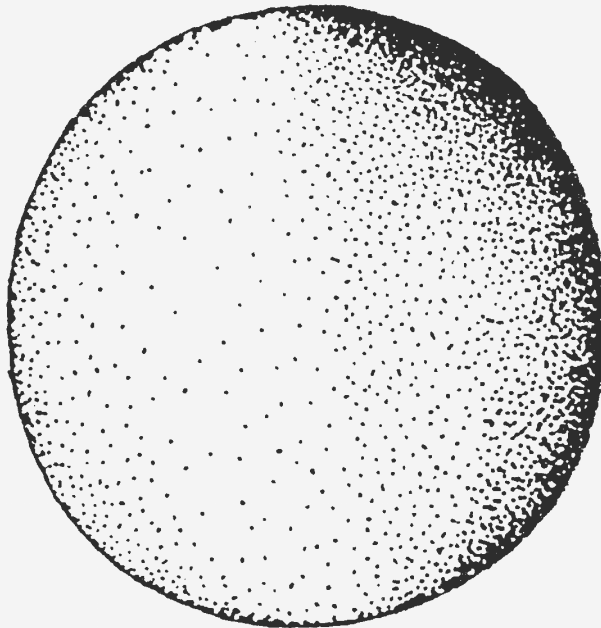
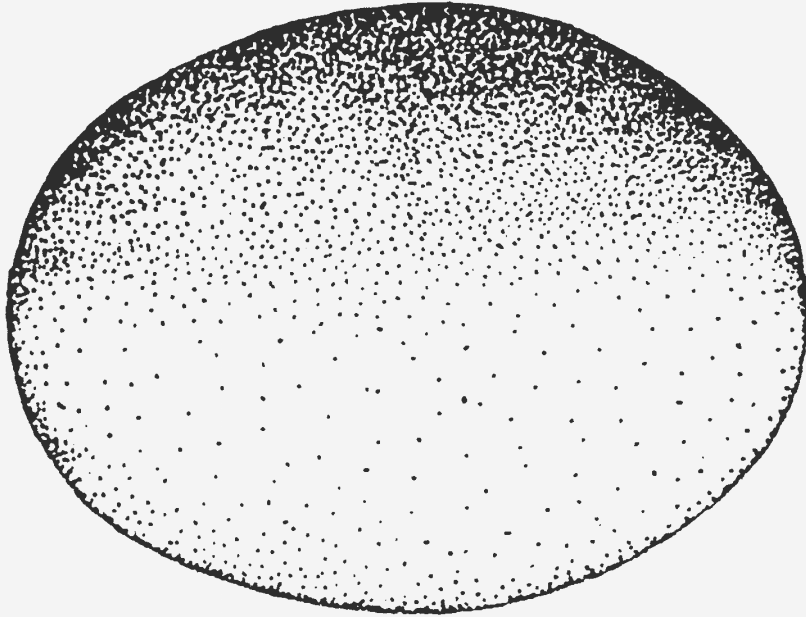


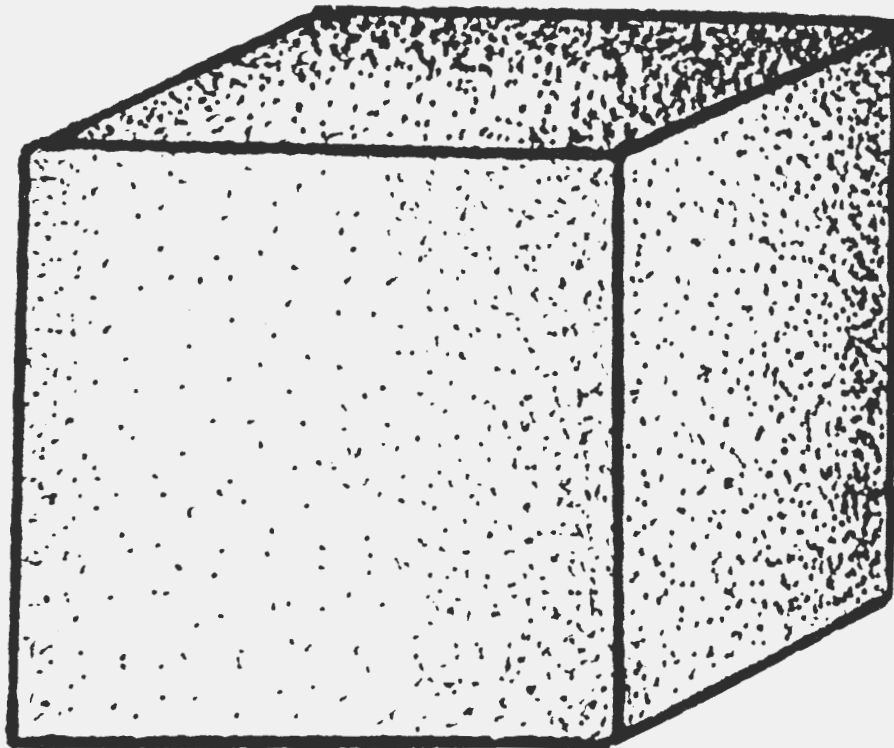




Pollen sacs split
exposing pollen

Structure of an anther (top cut off)

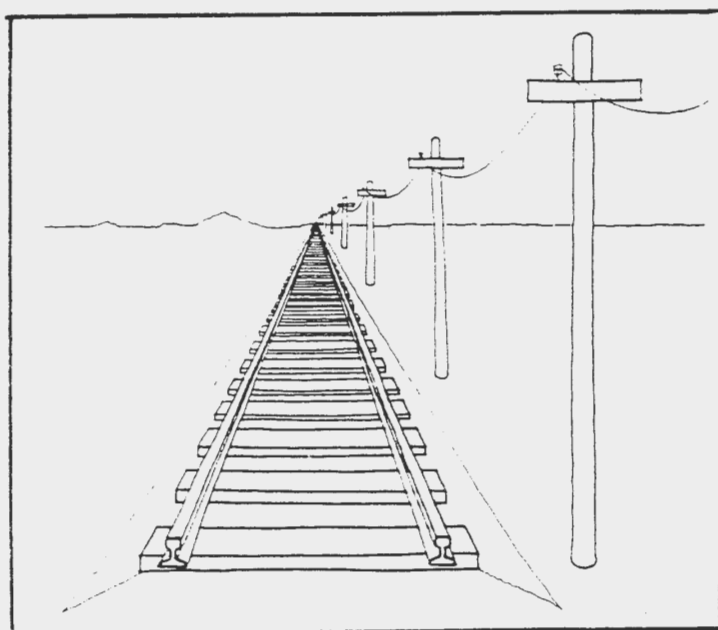
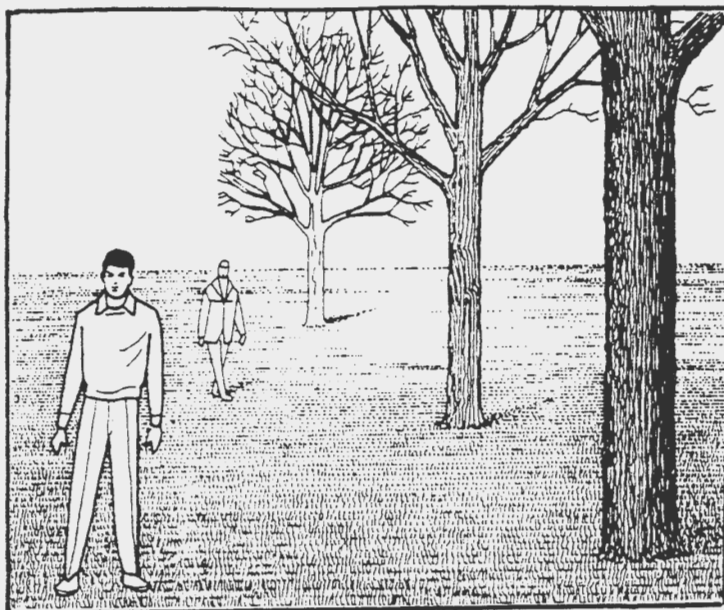


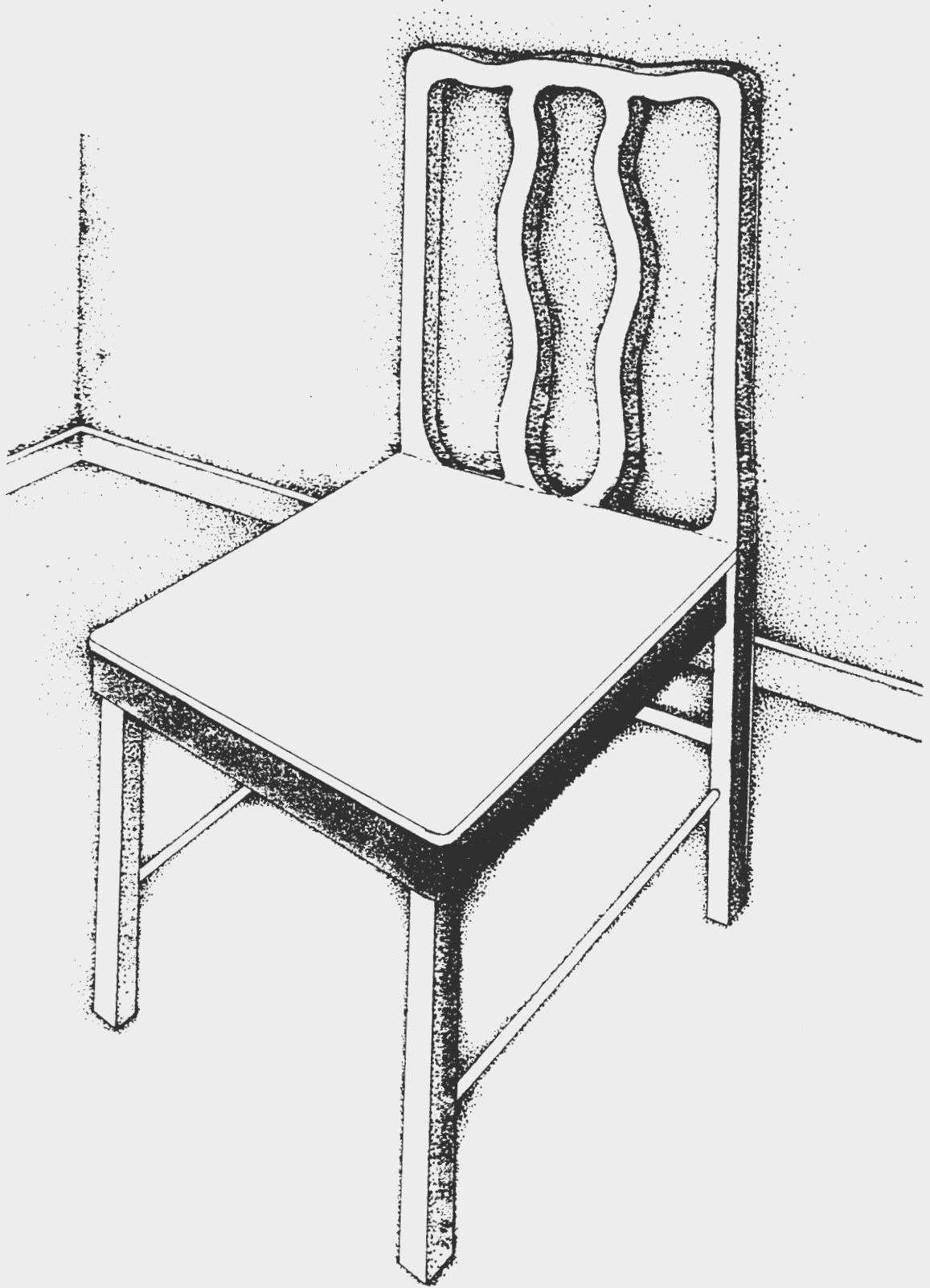


Depth cues used by artists (to give the impression of 3-D)



shading
overlapping
distortion of angles
shortening of lines
decreasing size





Much of the material used in the following exercises has been obtained from the following sources:

1. The Assessment of Ability in Science tests, developed as part of the ESTEAM Project at the University of Warwick (Perryman and Purcell, 1983). These materials are free of copyright restrictions when used in schools.
2. The Girls in Science and Technology Project (GIST, 1980). These were kindly provided by two of the workers involved in the project, Barabara Smail and Alison Kelly.
3. Dr W Macnab, who developed the exercises for her PhD (whilst associated with The University of Glasgow), and kindly gave her permission for their use in this project.

These sources are acknowledged, and the people involved are thanked for their permission to use the items.

PRACTICE EXERCISE: Hidden figures

The skill involved here is to try to concentrate on a specific pattern, while ignoring all the distracting background.

Biologists need this ability when they are viewing a slide under the microscope, as they have to pick out the areas of the slide which they wish to examine in detail. They must be able to ignore all the parts of the slide which are not relevant to them. Biology pupils, and even university students, often struggle with this skill.

HINTS:

Try to fix the "shape" in your mind. Which parts of the shape have a very characteristic and recognisable feature? For example, in the shape shown here, the curve on the top, the blunt dented "nose", and the tapering tail might be easy to recognise.

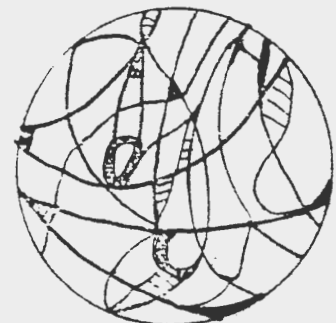
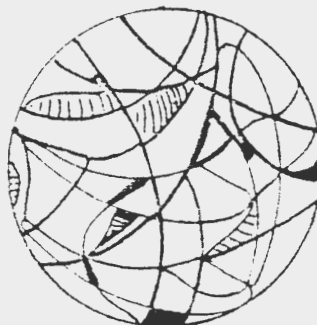
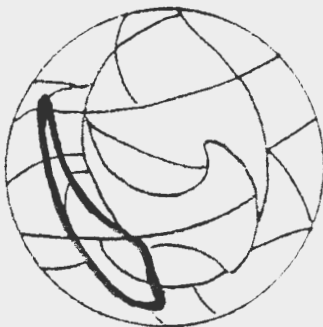


Now run your eye over the picture, and look for "recognisable bits" rather than the whole shape.

Don't be distracted by all the other lines which might cross over the shape you are looking for.

Once you have found the "bit", see if the rest of the shape is there. Outline it in coloured ink each time you find it.



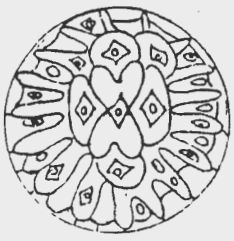
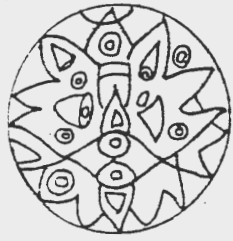








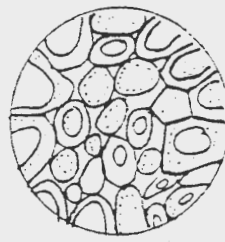

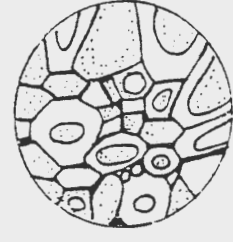





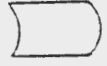
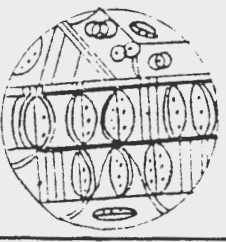
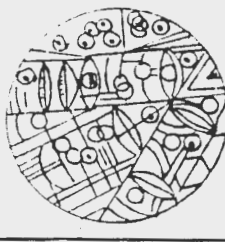
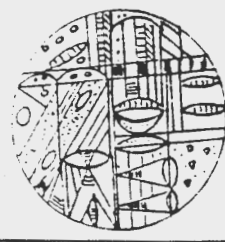

Try this example, where the first one has been done for you, before going on to the practice ones over the page.



For each question, examine the shape in the box on the LEFT of the question, and then try to find that shape in each of the four pictures on the RIGHT.

Outline the shape in red ink each time you find it.

NB: The shape may occur more than once in each picture. Try to find ALL the shapes

Shape to look for	Pictures in which the shapes may be found			
1. 				
2. 				
3. 				
4. 				
5. 				

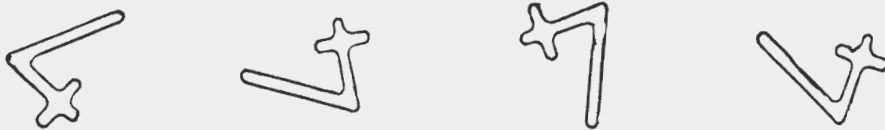
PRACTICE EXERCISE: Rotate-and-flip

In this exercise you need to be able to turn pictures in your mind.

Biologists need this skill when they are looking at something under the microscope, and it is not the right way up on the slide. They must then be able to "turn" the image in their mind. Many school pupils and university students struggle to recognise what they are looking at under the microscope, because the specimen is not "the right way up".

Each question shows five diagrams. Four of them are identical, except that they have been turned around **without lifting them off the page**. But one of the diagrams in each question has not only been turned around on the page. It has also been lifted and flipped over, so it is actually back-to-front.

e.g. all of the diagrams in this row have been turned but are the same

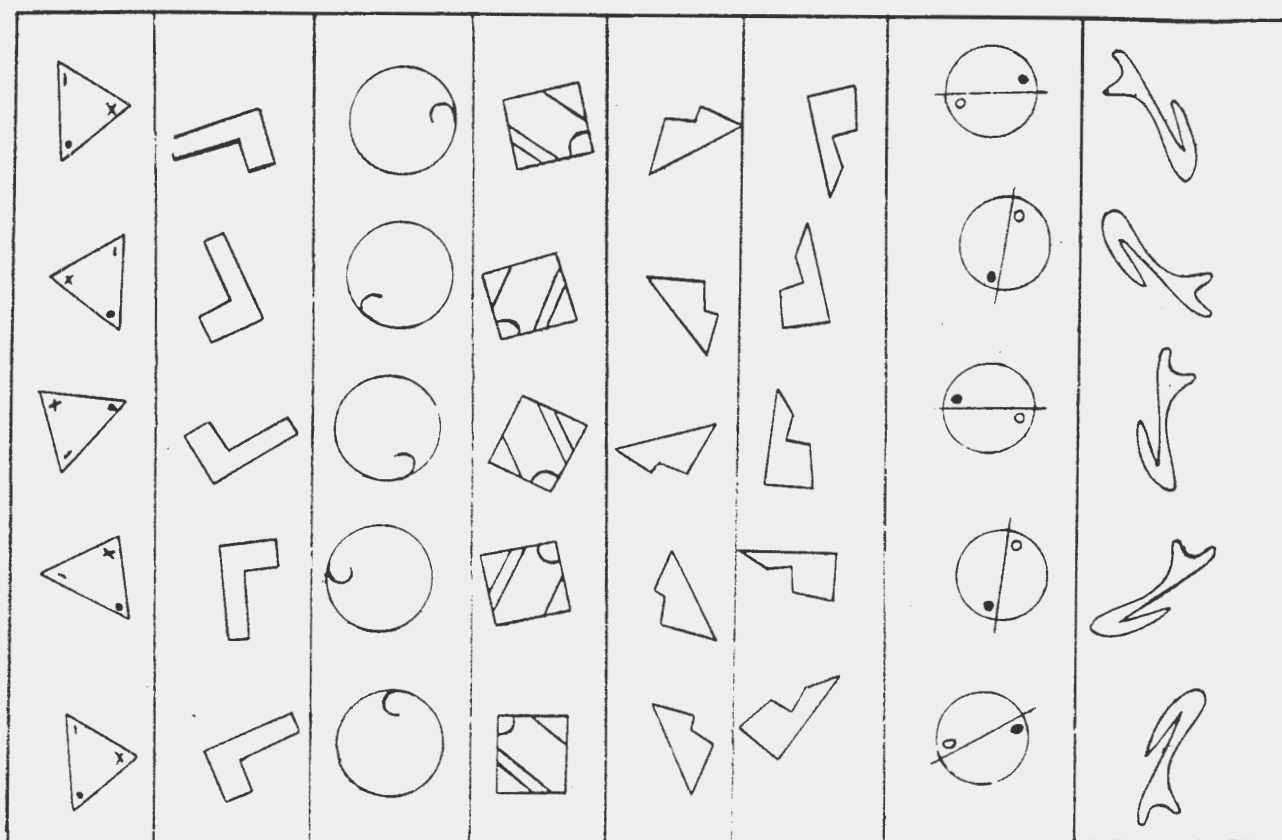
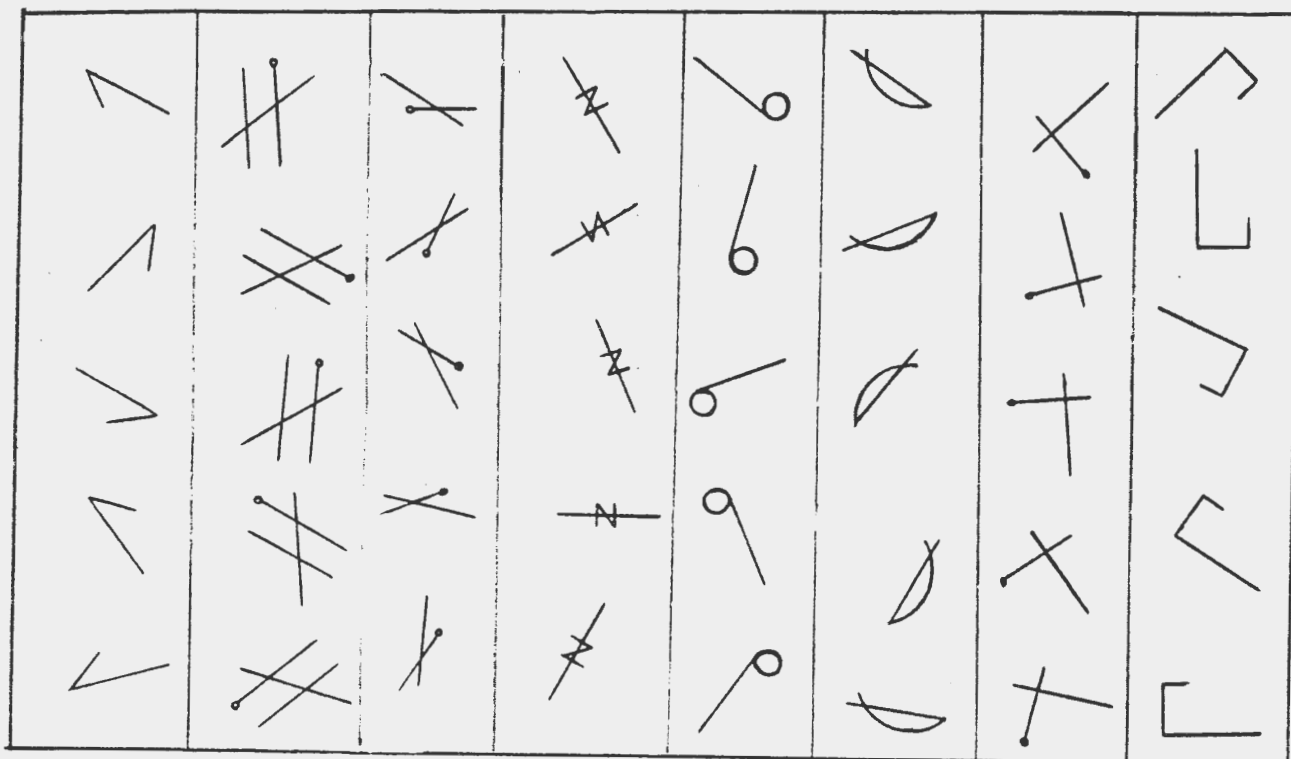


... but these two diagrams are **different** because one is back-to-front.



In each question, find the one which is different, and circle it.

Which is the odd-man-out in each row, because it has been slid around on the paper AND FLIPPED OVER (to form a mirror image of the other four shapes).



PRACTICE EXERCISE: Mental rotation in 3-D

This skill is similar to the one in the rotate-and-flip exercise, but it requires that you be able to mentally turn a picture in three dimensions.

Each problem in the test consists of drawings of two blocks. Remember that there is a **different** letter, number or design on each face of any given block.

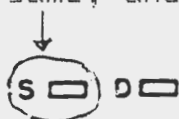
You need to decide if the two cubes **could be the same** or if you can see from the diagrams that they **are definitely different**.

e.g. In this example, the blocks are DIFFERENT. To check this, you need to imagine turning the first block in your mind, to try and match it to the second block.



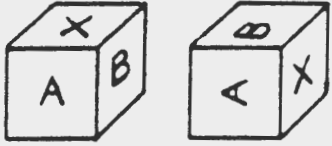
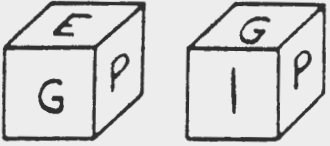
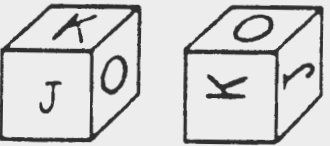
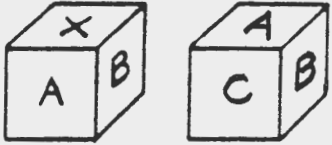
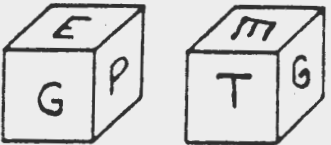
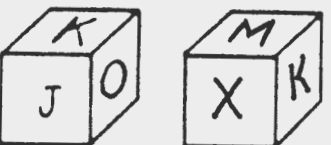
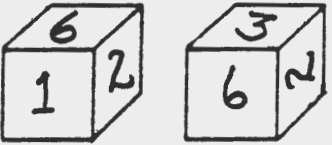
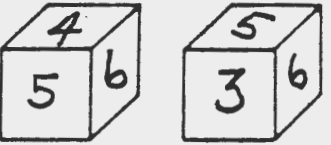
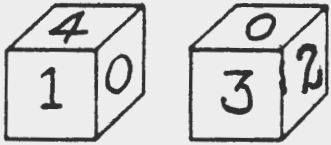
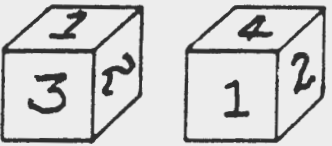
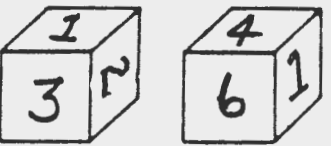
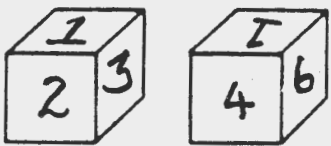
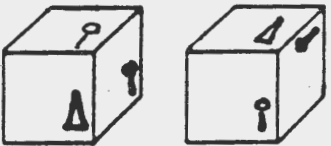
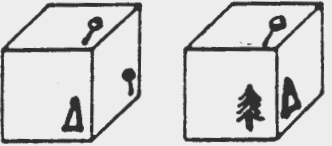
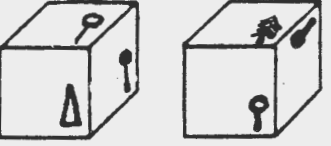
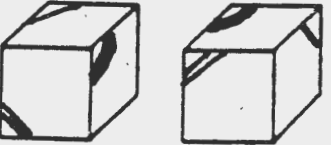

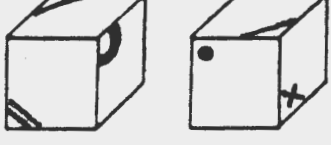
If the block on the left is turned so the A is upright on the front face (to match the second block), the N would be on the LEFT SIDE of the A, and therefore hidden from view. It would not be on the right side of the A as in the diagram of the second block. Thus the two blocks must be different.

For each question in this exercise, circle the S if the two blocks are the same, and the D if the two are different.



Could the two blocks in each question be the SAME, or are they definitely DIFFERENT?

Place a cross in the box marked "S" if they are the SAME, and a cross in the box marked "D" if they are DIFFERENT.

 <p>S <input type="checkbox"/> D <input type="checkbox"/></p>	 <p>S <input type="checkbox"/> D <input type="checkbox"/></p>	 <p>S <input type="checkbox"/> D <input type="checkbox"/></p>
 <p>S <input type="checkbox"/> D <input type="checkbox"/></p>	 <p>S <input type="checkbox"/> D <input type="checkbox"/></p>	 <p>S <input type="checkbox"/> D <input type="checkbox"/></p>
 <p>S <input type="checkbox"/> D <input type="checkbox"/></p>	 <p>S <input type="checkbox"/> D <input type="checkbox"/></p>	 <p>S <input type="checkbox"/> D <input type="checkbox"/></p>
 <p>S <input type="checkbox"/> D <input type="checkbox"/></p>	 <p>S <input type="checkbox"/> D <input type="checkbox"/></p>	 <p>S <input type="checkbox"/> D <input type="checkbox"/></p>
 <p>S <input type="checkbox"/> D <input type="checkbox"/></p>	 <p>S <input type="checkbox"/> D <input type="checkbox"/></p>	 <p>S <input type="checkbox"/> D <input type="checkbox"/></p>
 <p>S <input type="checkbox"/> D <input type="checkbox"/></p>	 <p>S <input type="checkbox"/> D <input type="checkbox"/></p>	 <p>S <input type="checkbox"/> D <input type="checkbox"/></p>

PRACTICE EXERCISE: Paper-folding

This exercise tests your ability to imagine a mirror image of any picture you see.

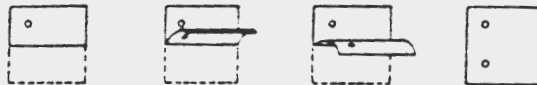
Biologists often use this skill, because many living things are **symmetrical**. This means that some parts are mirror images of others. Biological diagrams sometimes only show one half of the organism (e.g. in the cross-section of an earthworm shown below), and the biologist needs to be able to imagine what the other half looks like.

You need to imagine that a square of paper is folded up, and a hole punched through all thicknesses of the paper.

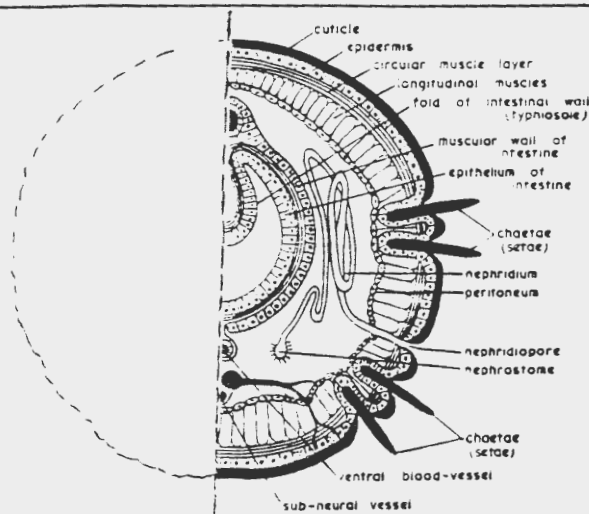
e.g.



What would the paper look like if it was unfolded? Circle the correct answer.



NB: In the questions over the page a corner of the square has been cut off in each case, to help you see which way round the paper is lying.



Cross-section of the Earthworm

A square of paper is folded as shown on the LEFT, and holes are punched or cut in it. One corner of the paper is cut off to act as a reference point.

Which of the diagrams on the RIGHT show what the sheet of paper would look like if opened out? Circle the correct diagram.

Paper folded	Possible patterns when the paper is unfolded			

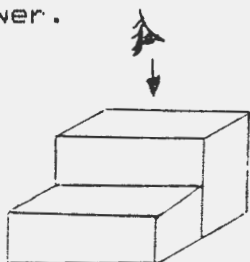
PRACTICE EXERCISE: View-from-the-top

This exercise checks your ability to imagine turning a 3-D model so you are looking down on it from above.

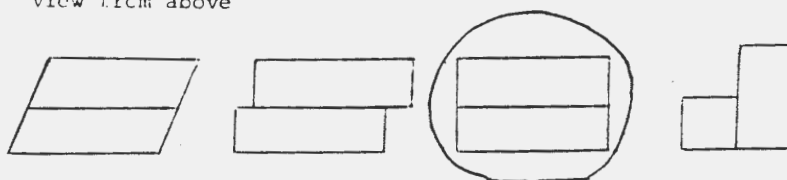
Biologists need to be able to turn images in their minds, if they are to understand fully the relationships between biological sections and the whole structures from which they are cut.

Imagine floating above the model, looking down on it. What would you see?

Circle the correct answer.



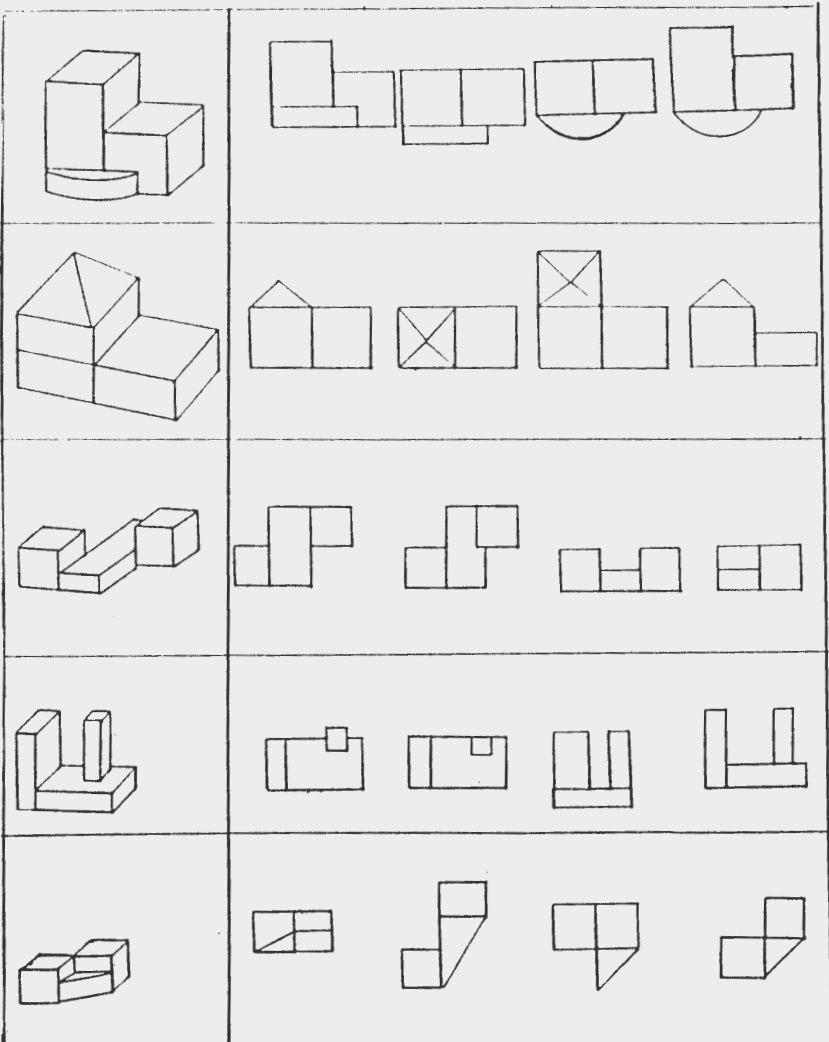
View from above



Find the drawing which shows what the model would look like if you
looked down on it from above, Draw a circle around the correct answer

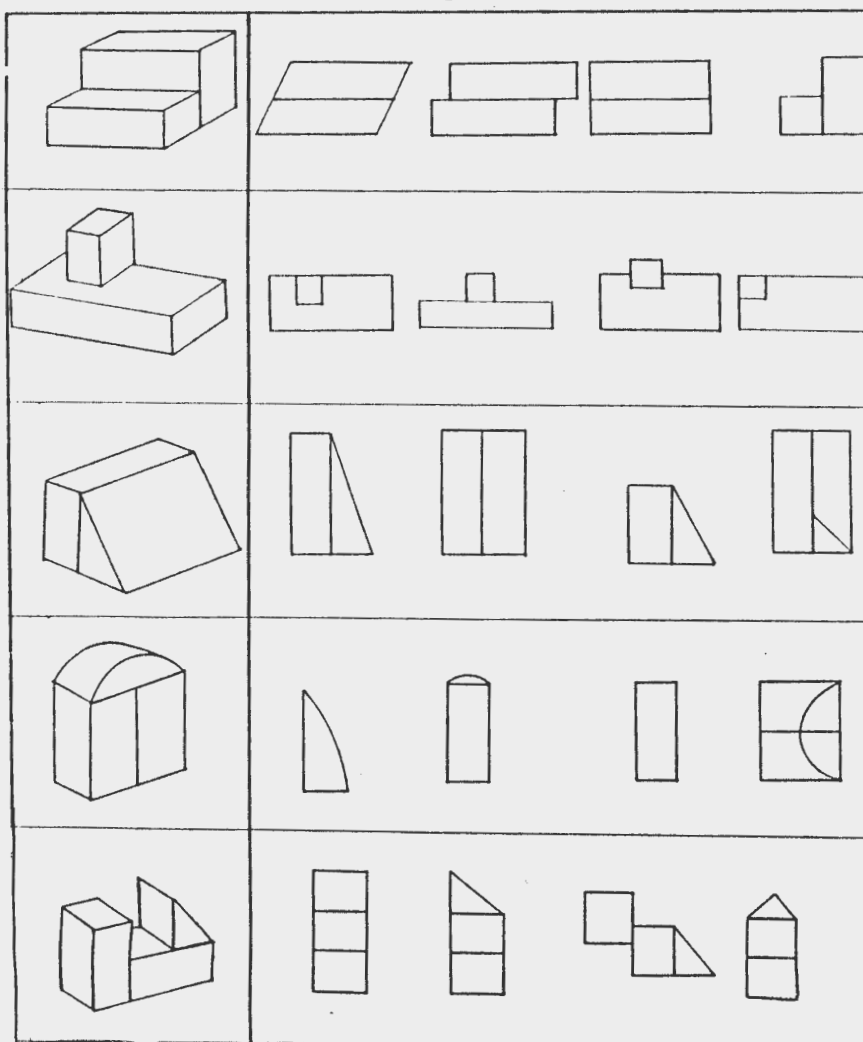
MODEL

POSSIBLE VIEWS FROM ABOVE



MODEL

POSSIBLE VIEWS FROM ABOVE



PRACTICE EXERCISE: Find-the-missing-shapes

This exercise checks your ability to turn pictures in your mind. It also sees how well you can recognise and match shapes.

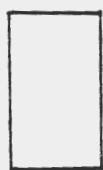
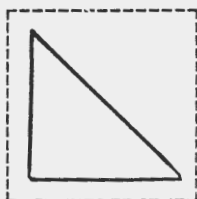
In the box on the left is a diagram of an incomplete square. On the right are four possible missing pieces. Which is the one which would complete the square?

HINTS

Remember that all sides of a square are of equal length.

First try and imagine what the shape of the missing piece must be. Then look for this shape among the options provided. Remember that it might have been turned around on the page, to try and catch you out, but it **cannot be flipped over** to make it fit.

e.g.



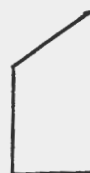
A



B



C



D

In this square, the missing piece must be a triangle. about the same size as the piece already there, so it must be option C.

Which of the four shapes on the RIGHT (in each question) is the correct shape to complete the incomplete square shown on the LEFT?
Circle the correct answer.

Incomplete square	Possible missing pieces
	Four triangles: 1. A small right-angled triangle with the hypotenuse on the left. 2. A larger right-angled triangle with the hypotenuse on the left. 3. A small right-angled triangle with the hypotenuse on the right. 4. A larger right-angled triangle with the hypotenuse on the right.
	Four L-shaped pieces: 1. A small L-shape with the missing corner at the bottom-left. 2. A larger L-shape with the missing corner at the bottom-left. 3. A small L-shape with the missing corner at the top-right. 4. A larger L-shape with the missing corner at the top-right.
	Four triangles: 1. A small right-angled triangle with the hypotenuse on the left. 2. A larger right-angled triangle with the hypotenuse on the left. 3. A small right-angled triangle with the hypotenuse on the right. 4. A larger right-angled triangle with the hypotenuse on the right.
	Four L-shaped pieces: 1. A small L-shape with the missing corner at the top-right. 2. A larger L-shape with the missing corner at the top-right. 3. A small L-shape with the missing corner at the bottom-left. 4. A larger L-shape with the missing corner at the bottom-left.
	Four triangles: 1. A small right-angled triangle with the hypotenuse on the left. 2. A larger right-angled triangle with the hypotenuse on the left. 3. A small right-angled triangle with the hypotenuse on the right. 4. A larger right-angled triangle with the hypotenuse on the right.
	Four triangles: 1. A small right-angled triangle with the hypotenuse on the left. 2. A larger right-angled triangle with the hypotenuse on the left. 3. A small right-angled triangle with the hypotenuse on the right. 4. A larger right-angled triangle with the hypotenuse on the right.
	Four triangles: 1. A small right-angled triangle with the hypotenuse on the left. 2. A larger right-angled triangle with the hypotenuse on the left. 3. A small right-angled triangle with the hypotenuse on the right. 4. A larger right-angled triangle with the hypotenuse on the right.
	Four triangles: 1. A small right-angled triangle with the hypotenuse on the left. 2. A larger right-angled triangle with the hypotenuse on the left. 3. A small right-angled triangle with the hypotenuse on the right. 4. A larger right-angled triangle with the hypotenuse on the right.

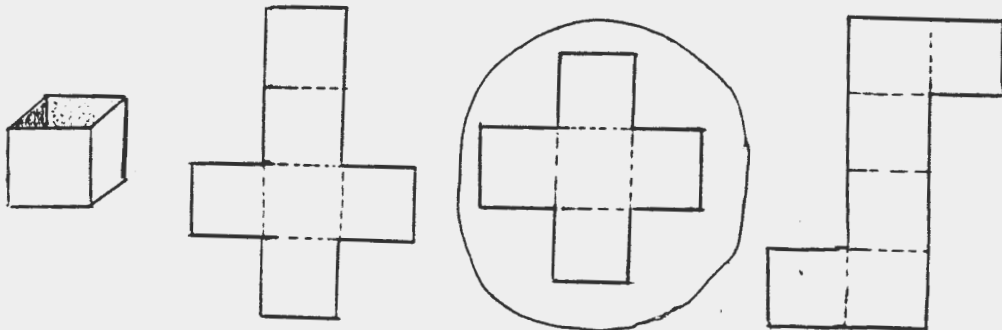
PRACTICE EXERCISE: Making-the-cardboard-model

This exercise tests your ability to imagine a 2-D picture, and to bend and fold it in your mind, to form a 3-D model.

This skill is very important in biologists because when they see a diagram of a section through a living thing they need to be able to imagine the whole specimen from which it was cut.

You must decide which of the flat cardboard shapes on the right, if bent along the dotted lines, could form the 3-D shape represented on the left.

eg.



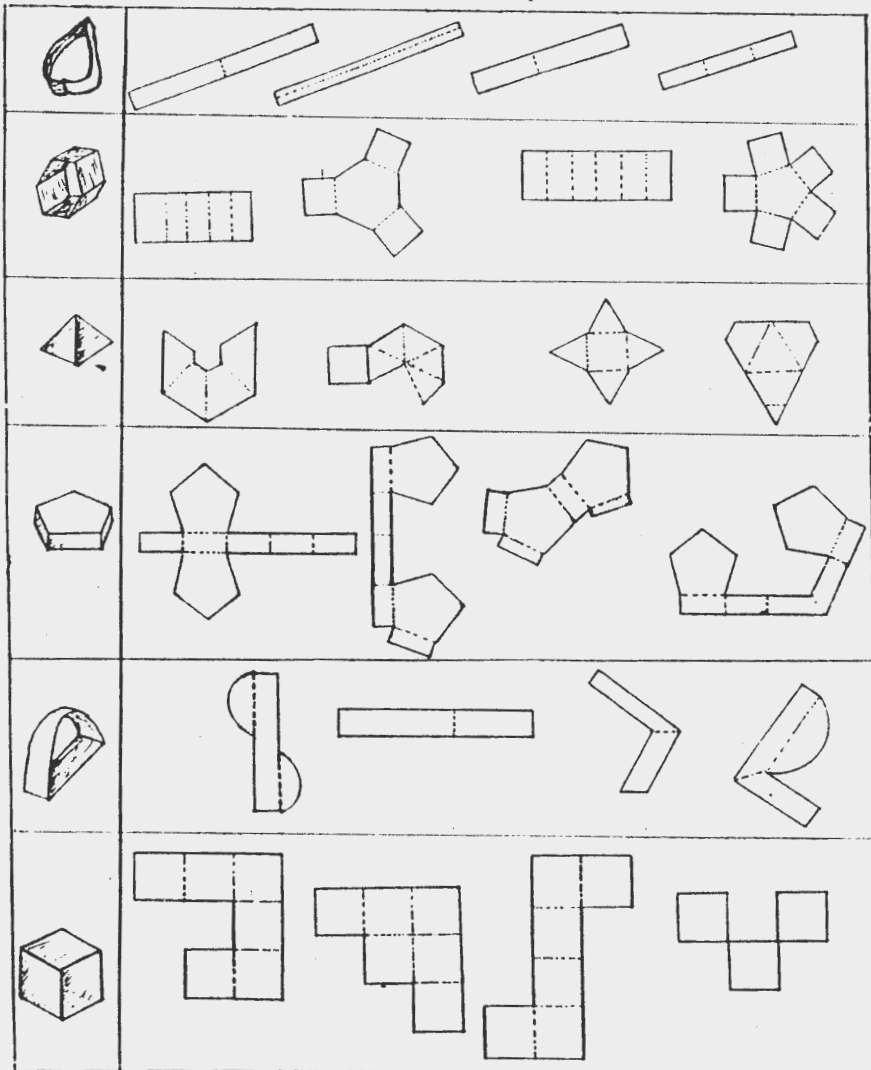
In this section each question has a picture of a model made by folding a stiff card cut-out-shape.

Besides the picture of the model are 4 drawings of cut out shapes. Choose the shape which when folded would make the model shown in the picture. (dotted lines represent folds)

Circle the cut-out shape you choose.

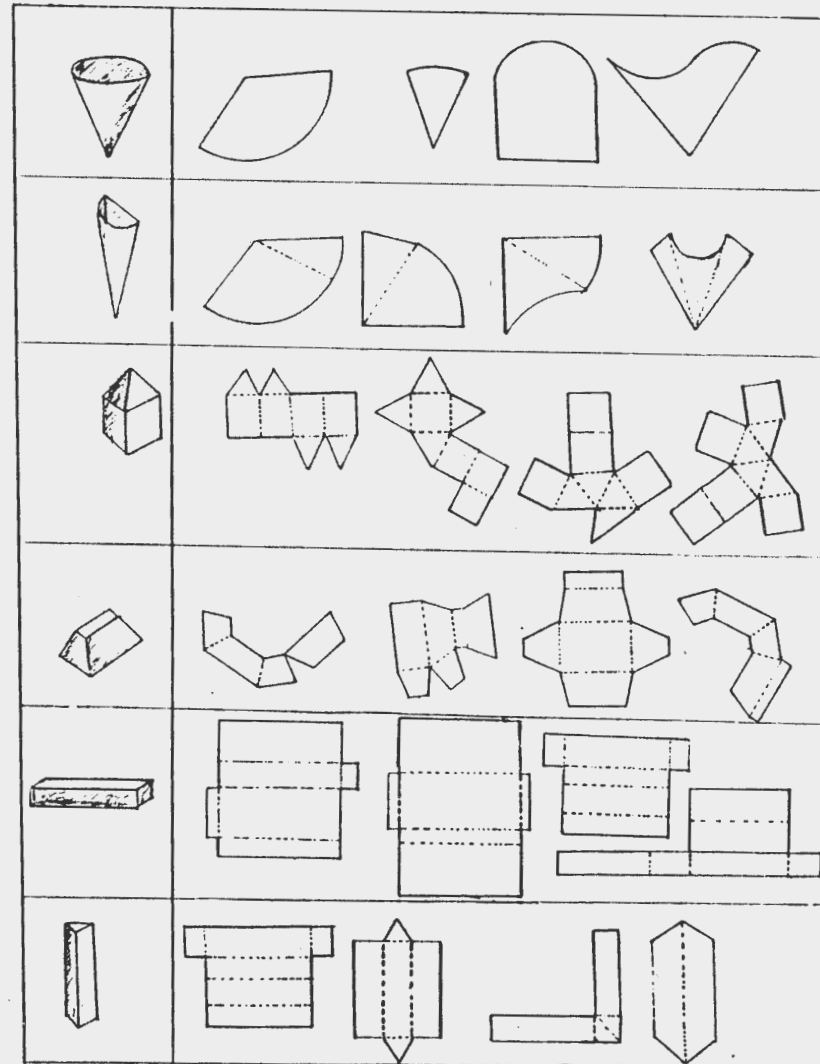
Model made from stiff card

Cut-out shapes



Model made from stiff card

Cut-out shapes



PRACTICE EXERCISE: Sawing-through-the-shape

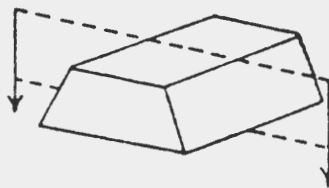
This exercise checks your ability to see a 2-D diagram as it would appear in 3-D, and to imagine sawing it in half, and predicting what the cut side would look like if viewed face-on.

This skill is vitally important in biologists, as they need to be able to imagine what biological structures will look like if they are sectioned so that you can see what they look like inside.

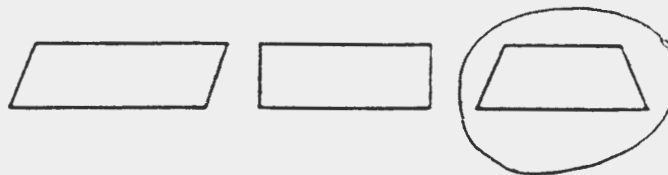
HINTS

First look at the shape, and try and imagine it in 3-D.

Then imagine sawing through it in the direction indicated by the dotted lines and arrows.



Imagine separating the two halves, and turning one to face you. What shape would it be?



Circle the correct answer.

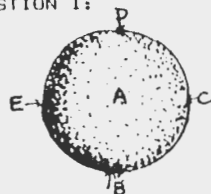
What would the shape on the LEFT look like if it was sawn in half (as shown by the dotted line and arrows) and the cut half viewed from the front?

Circle the correct answer from the four options on the RIGHT.

Can you interpret stereograms?

A stereogram is a diagram where the artist has used depth cues to give the impression of 3-D. This exercise is to see how well you can interpret the depth cues. Do you see what the artist meant you to see?

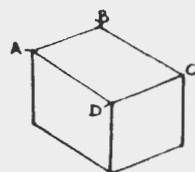
QUESTION 1:



Which of the points A, B, C, D or E is CLOSEST to you? _____

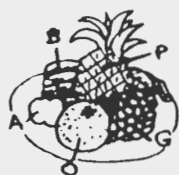
Which point/points is/are FURTHEST from you, the viewer? _____

QUESTION 2:



How far are the points A, B, C and D from you (the viewer)? Write down the letters in order of closeness, starting with the CLOSEST and ending with the FURTHEST.

QUESTION 3:

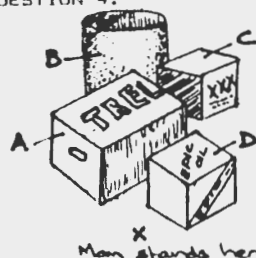


Carefully examine the diagram of a bowl of fruit (A=apple, B=banana, G=grapes, D=orange, P=pineapple).

Decide how close each fruit is to the viewer (you).

List the letters in order of distance, starting with the one FURTHEST from you, and ending with the CLOSEST.

QUESTION 4:



A man goes into a storeroom to fetch an empty container. He needs the one at the back. Write down the letter of the one he wants. _____

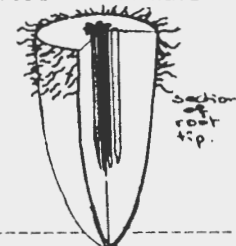
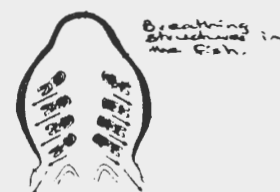
In order to reach it he will have to move the boxes in the way. Write down the letters of the boxes in the order in which he will have to remove them. _____

QUESTION 5:

The following diagrams represent sections cut through biological specimens. Colour in, with pencil or pen, the surfaces which have been CUT.



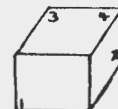
TRICARPEAL OVARY



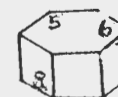
Section of root tip.

QUESTION 6:

Examine each of the numbered angles in these two drawings, and say if it is
a right angle ($= 90^\circ$)
an acute angle ($< 90^\circ$)
an obtuse angle ($> 90^\circ$)

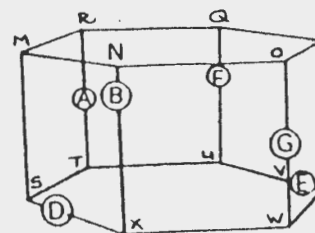


1. _____
2. _____
3. _____
4. _____



5. _____
6. _____
7. _____
8. _____

QUESTION 7:



Which letters are on the LID of the box shown here? _____
Which letters are on the BOTTOM of the box, and therefore touch the table on which it is resting? _____
Which ball, E or G, is closest to the left side of the box? _____
Which ball, B or G, is at the same height as ball A? _____
Which ball, B or F, is higher up? _____

FINAL TASK TO DO AT HOME:

Use plasticine, or a dough (see recipe below), to make small models of each of the following shapes. Check with your classmates to see if they think you are correct. Consult your teacher if there is any doubt



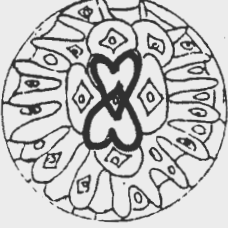





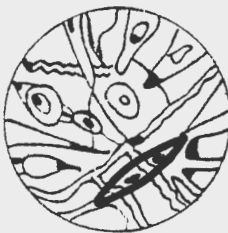


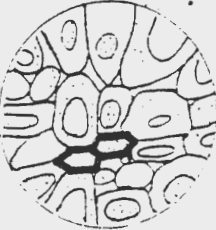
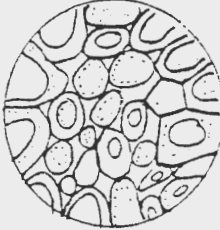
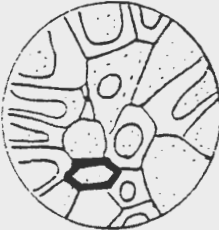




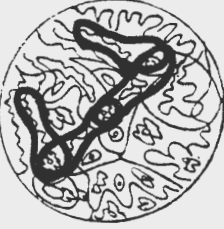


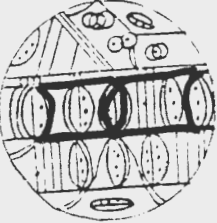
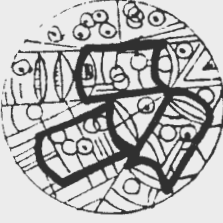
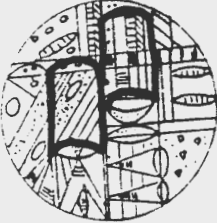
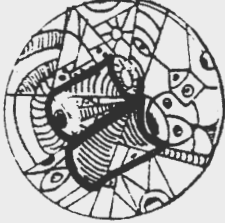


Mix 1 cup flour and half a cup of salt in a bowl. Slowly add water (about quarter of a cup) to make the mixture pliable. Add 1 tablespoon of oil to prevent the dough hardening.

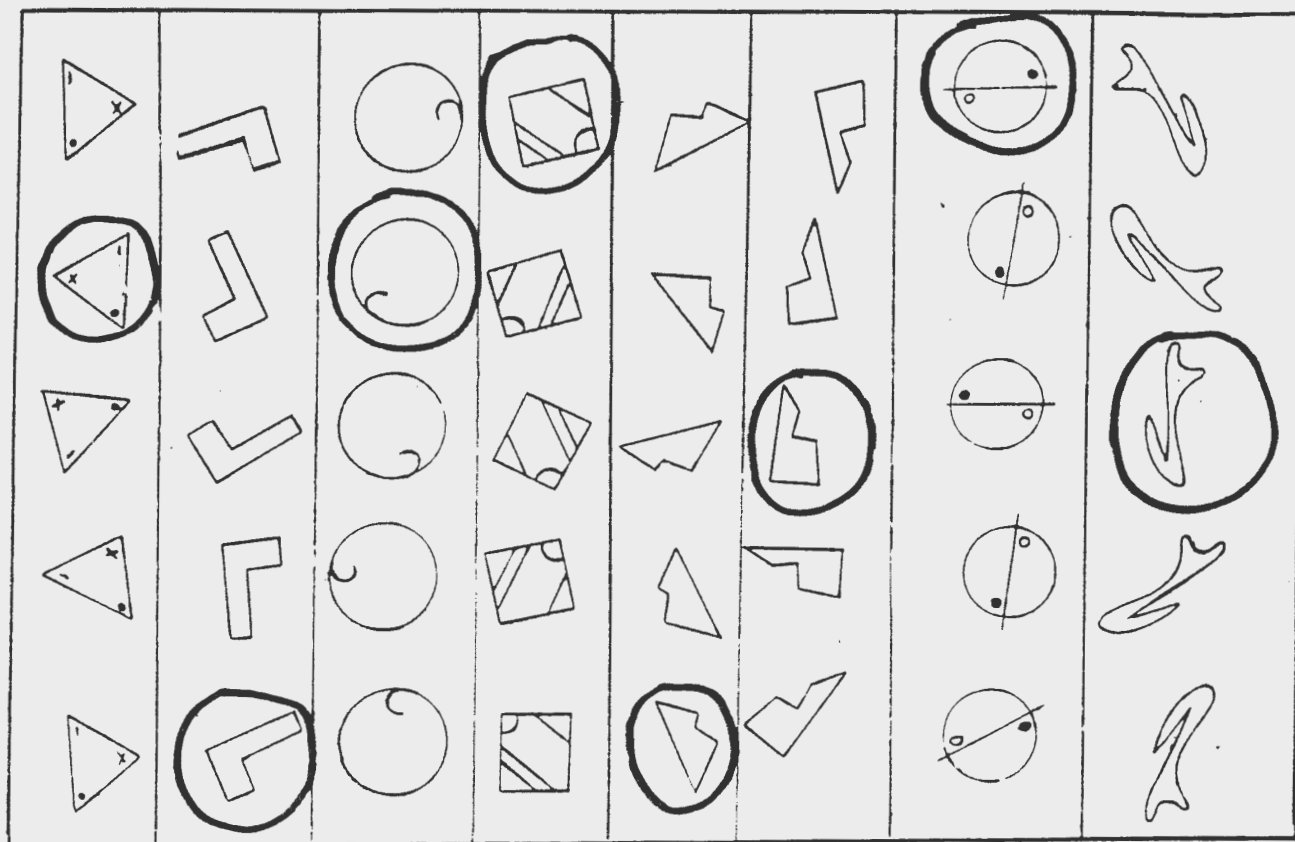
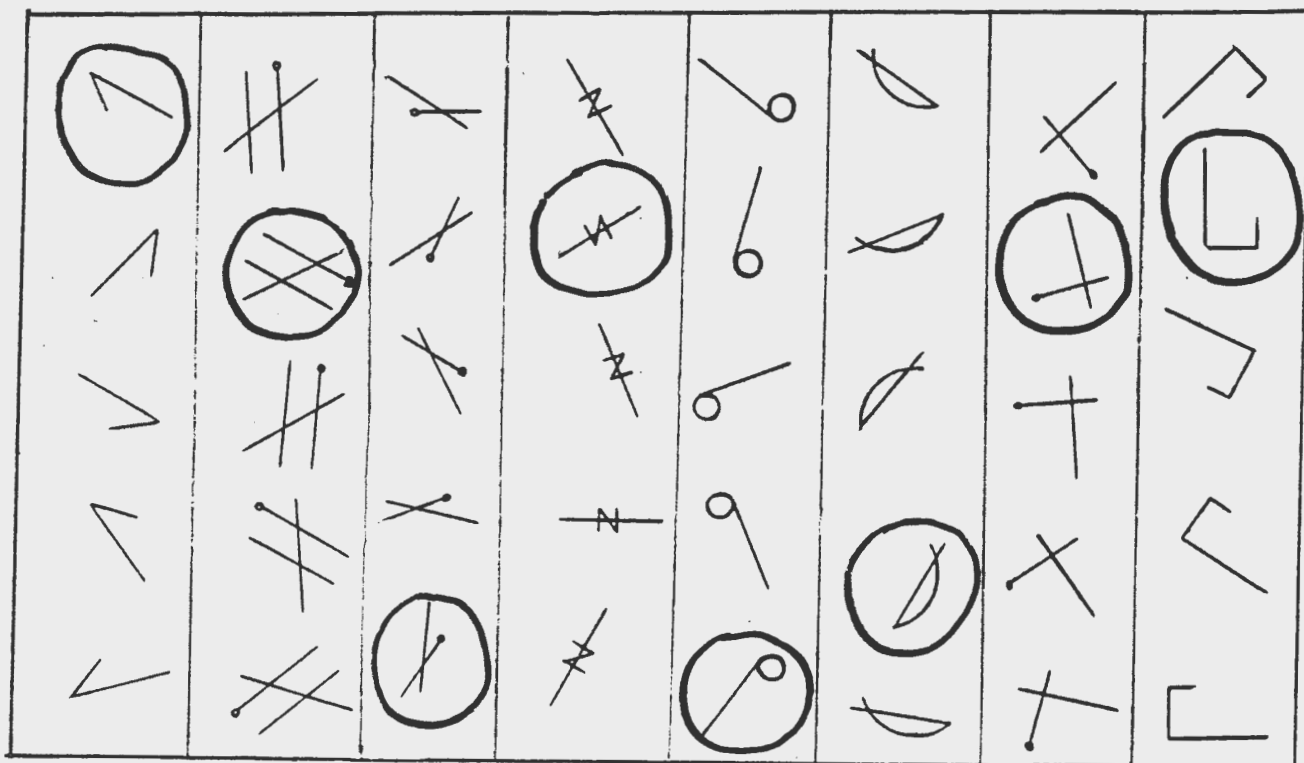
For each question, examine the shape in the box on the LEFT of the question, and then try to find that shape in each of the four pictures on the RIGHT.

Outline the shape in red ink each time you find it.

NB: The shape may occur more than once in each picture. Try to find ALL the shapes

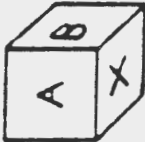
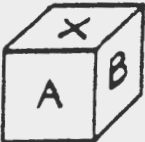
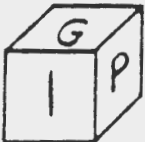
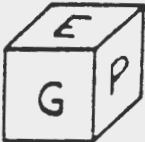
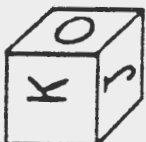
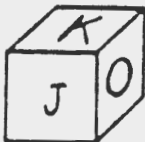
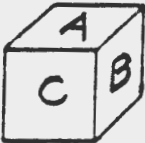
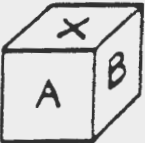
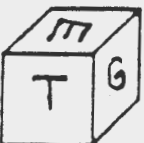

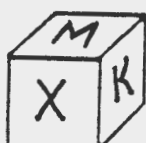
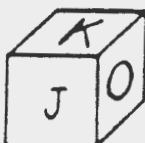
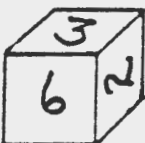
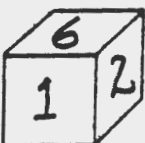

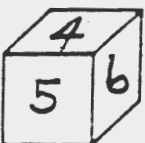
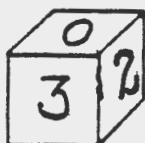
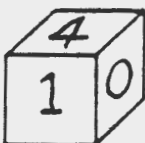
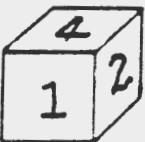
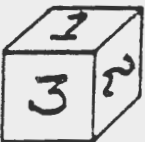
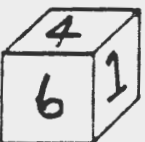
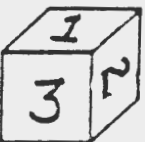
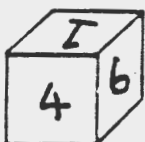
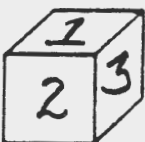
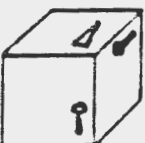
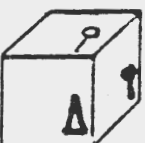

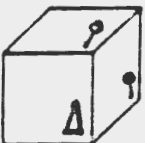
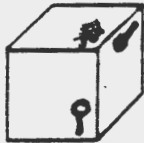
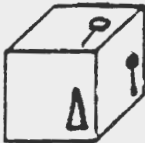
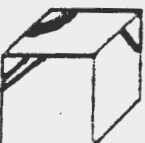
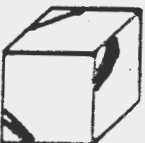
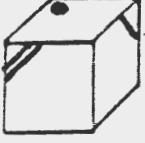
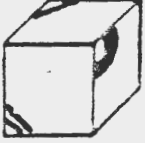
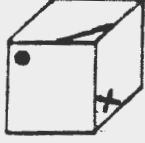
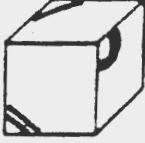
Shape to look for	Pictures in which the shapes may be found			
1. 				
2. 				
3. 				
4. 				
5. 				

Which is the odd-man-out in each row, because it has been slid around on the paper AND FLIPPED OVER (to form a mirror image of the other four shapes).



Could the two blocks in each question be the SAME, or are they definitely DIFFERENT?

Place a cross in the box marked "S" if they are the SAME, and a cross in the box marked "D" if they are DIFFERENT.

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A square of paper is folded as shown on the LEFT, and holes are punched or cut in it. One corner of the paper is cut off to act as a reference point.

Which of the diagrams on the RIGHT show what the sheet of paper would look like if opened out? Circle the correct diagram.

Paper folded	Possible patterns when the paper is unfolded			

Find the drawing which shows what the model would look like if you looked down on it from above, Draw a circle around the correct answer

MODEL	POSSIBLE VIEWS FROM ABOVE

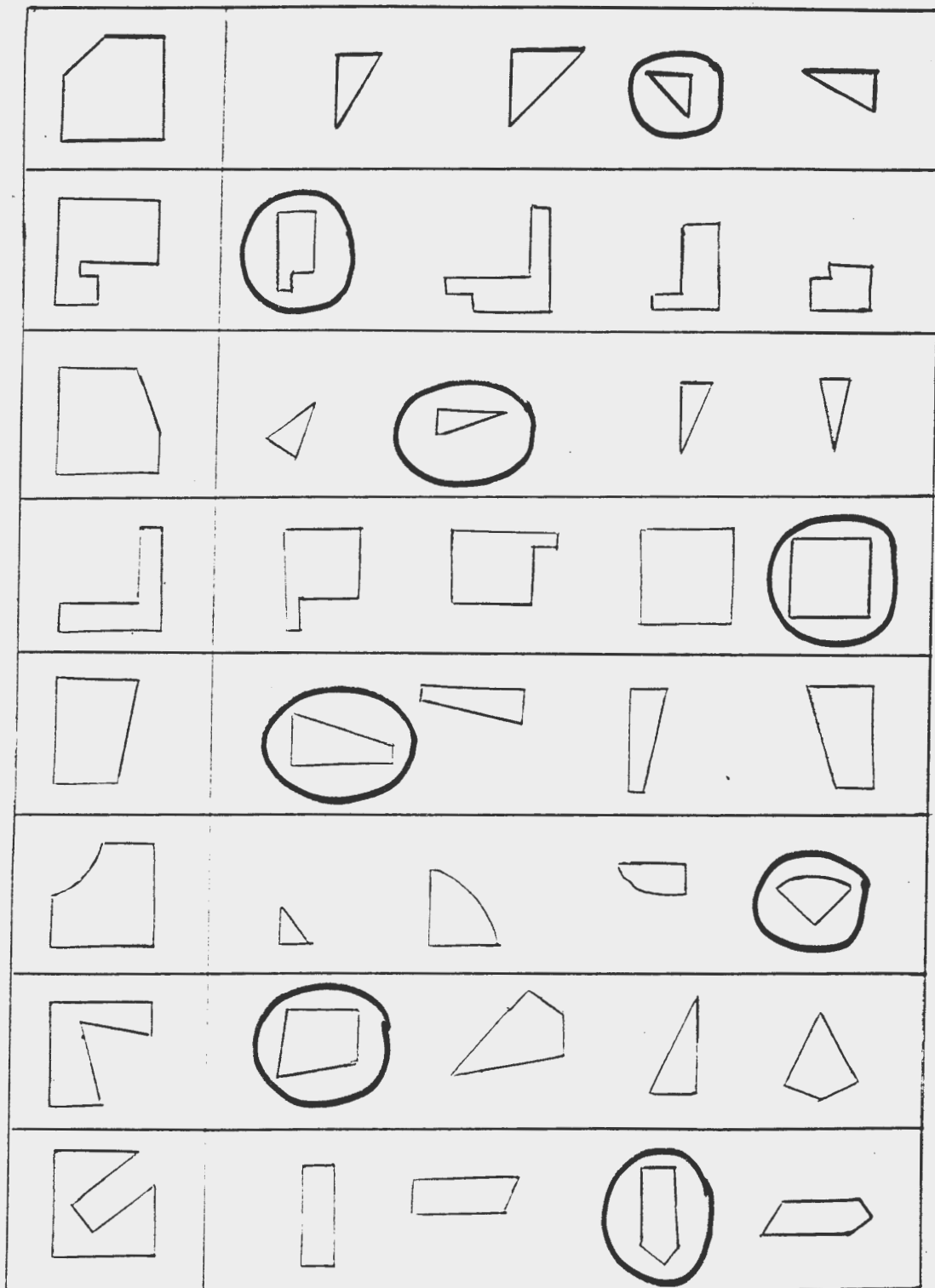
MODEL	POSSIBLE VIEWS FROM ABOVE

Which of the four shapes on the RIGHT (in each question) is the correct shape to complete the incomplete square shown on the LEFT?

Circle the correct answer.

Incomplete square

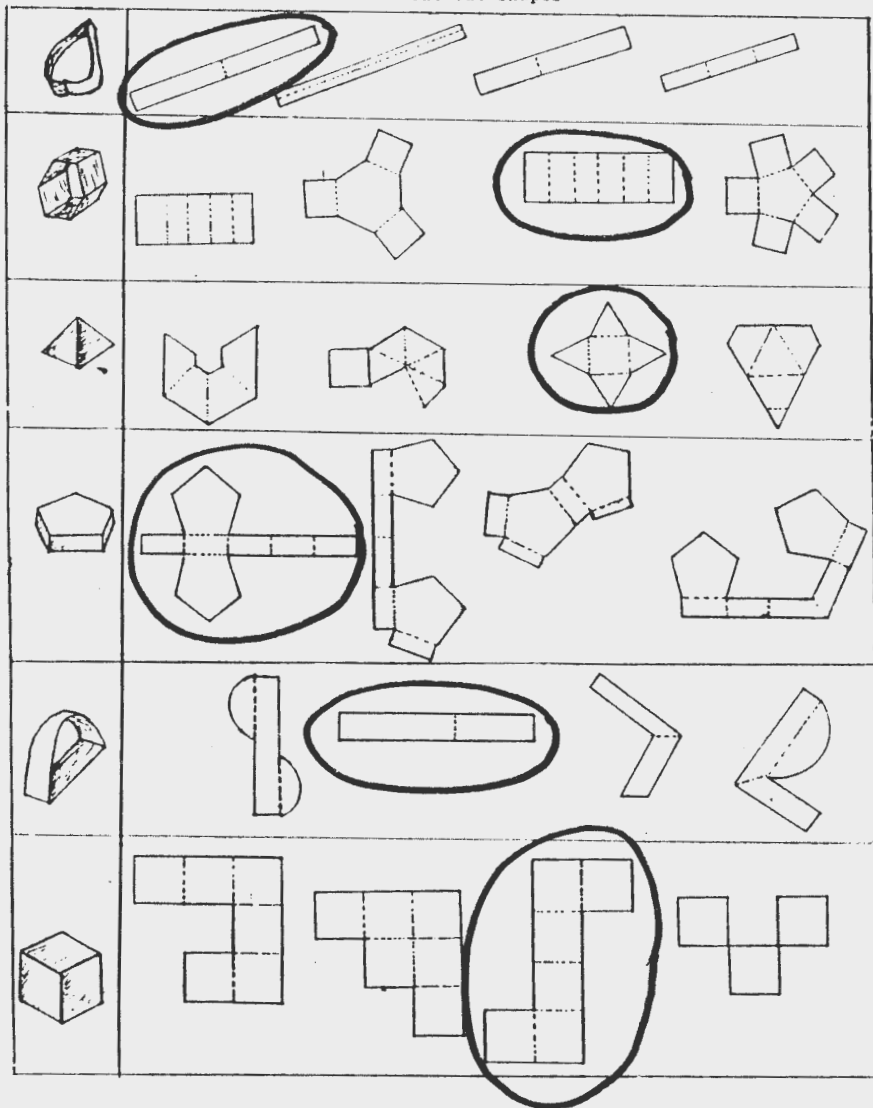
Possible missing pieces



In this section each question has a picture of a model made by folding a stiff card cut-out-shape.

Model made from stiff card

Cut-out shapes

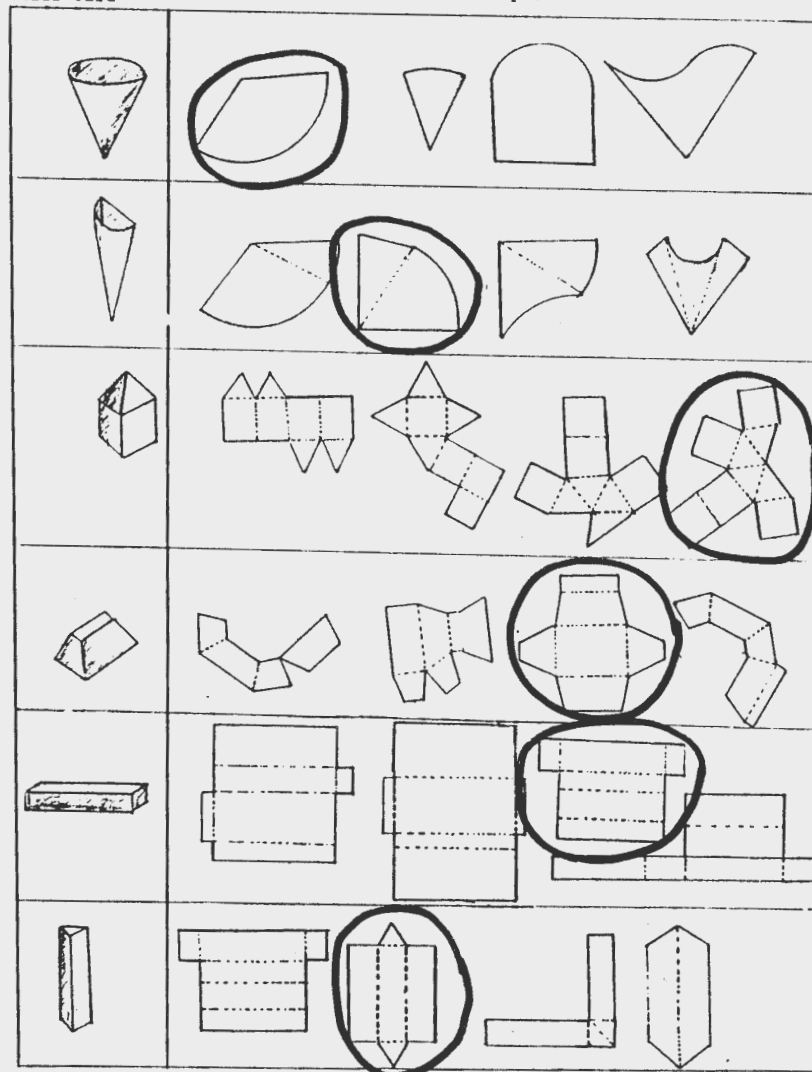


Besides the picture of the model are 4 drawings of cut out shapes. Choose the shape which when folded would make the model shown in the picture. (dotted lines represent folds)

Circle the cut-out shape you choose.

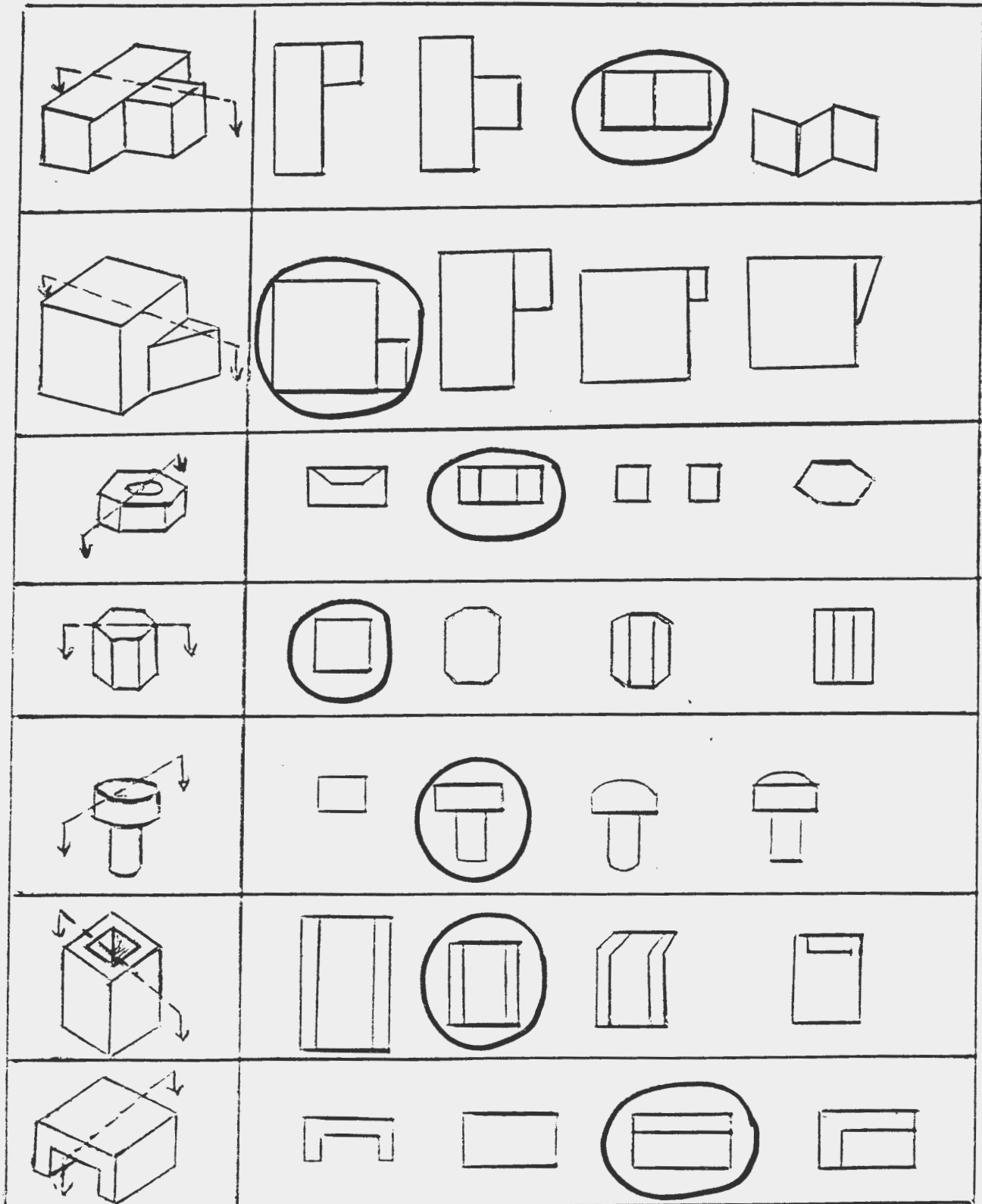
Model made from stiff card

Cut-out shapes



What would the shape on the LEFT look like if it was sawn in half (as shown by the dotted line and arrows) and the cut half viewed from the front?

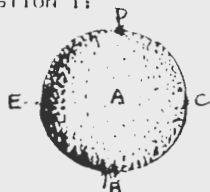
Circle the correct answer from the four options on the RIGHT.



Can you interpret stereograms?

A stereogram is a diagram where the artist has used depth cues to give the impression of 3-D. This exercise is to see how well you can interpret the depth cues. Do you see what the artist meant you to see?

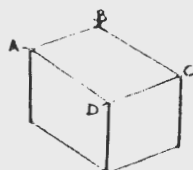
QUESTION 1:



Which of the points A, B, C, D or E is CLOSEST to you? **A**

Which point/points is/are FURTHEST from you, the viewer? **BCDE**

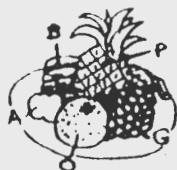
QUESTION 2:



How far are the points A, B, C and D from you (the viewer)? Write down the letters in order of closeness, starting with the CLOSEST and ending with the FURTHEST.

DCAB

QUESTION 3:



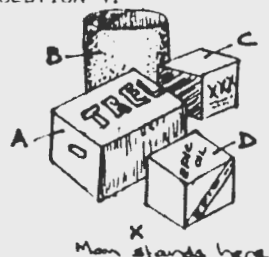
Carefully examine the diagram of a bowl of fruit (A=apple, B=banana, C=grapes, D=orange, E=pineapple).

Decide how close each fruit is to the viewer (you).

List the letters in order of distance, starting with the one FURTHEST from you, and ending with the CLOSEST.

BPAGO

QUESTION 4:

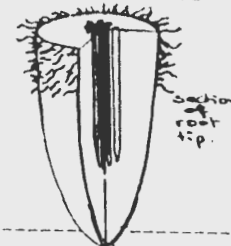
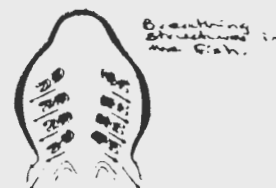


A man goes into a storeroom to fetch an empty container. He needs the one at the back. Write down the letter of the one he wants. **B**

In order to reach it he will have to move the boxes in the way. Write down the letters of the boxes in the order in which he will have to remove them. **DAC**

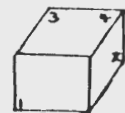
QUESTION 5:

The following diagrams represent sections cut through biological specimens. Colour in, with pencil or pen, the surfaces which have been CUT.

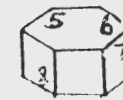


QUESTION 6:

Examine each of the numbered angles in these two drawings, and say if it is
a right angle ($= 90^\circ$)
an acute angle ($< 90^\circ$)
an obtuse angle ($> 90^\circ$)

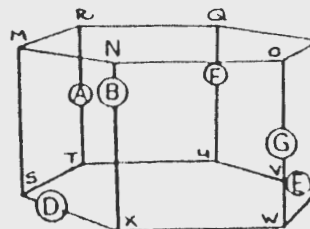


1. **90°**
2. **90°**
3. **90°**
4. **90°**



5. **$> 90^\circ$**
6. **$> 90^\circ$**
7. **90°**
8. **90°**

QUESTION 7:



Which letters are on the LID of the box shown here? **MNOPQR**
Which letters are on the BOTTOM of the box, and therefore touch the table on which it is resting? **STUVWX**
Which ball, E or G, is closest to the left side of the box? **G**
Which ball, E or G, is at the same height as ball A? **G**
Which ball, E or F, is higher up? **B**

FINAL TASK TO DO AT HOME:

Use plasticine, or a dough (see recipe below), to make small models of each of the following shapes. Check with your classmates to see if they think you are correct. Consult your teacher if there is any doubt



Mix 1 cup flour and half a cup of salt in a bowl. Slowly add water (about quarter of a cup) to make the mixture pliable. Add 1 table-spoon of oil to prevent the dough hardening.

Teacher's comments on lesson

School: _____ Teacher: _____ Lesson No. _____

Time spent on lesson: _____

How lesson was taught: Please mention briefly how the lesson was dealt with e.g. teacher demonstration, whole class exercise, small group work, individual pupil work etc.

When exercises were done: Please mention (for each exercise) if these were done in class, or for homework.

Checking of answers: Please indicate whether the pupils' answers were checked, and if so, how this was done (e.g. answers displayed on a board, and pupils given 5 minutes at start of lesson to check their homework, or teacher went over answers in class at the end of the lesson etc.)

COMMENTS

Problems experienced by teacher:

Problems experienced by the pupils:

General comments on the lesson:

LESSON 2

(The concept of sections)

Recommended time

A single lesson

Purpose of the lesson

1. To teach the skill of predicting the shapes of sections by careful observations of stereograms of whole structures.
2. To provide practice in these skills, using geometric shapes.

Requirements for lesson

1. Overhead transparencies:
 - root tip (from lesson 1)
 - does orientation matter ?
 - length-wise and cross-cuts
 - answer sheets (2) for pupil exercises
2. Pupil exercises: 1 per pupil
 - sectioning geometric shapes
 - brain-teaser exercise No. 1 (Answer: A coffee mug)
3. Models of geometric shapes
4. Answer sheets:
8 answer sheets for the remedial exercises from lesson 3, to display on the notice-board. (These were provided with the materials for Lesson 1).

Points to make to the pupils

1. Please ensure that the answers to the remedial exercises are checked, either by going over them with the whole class, or putting them on a display board and ensuring that the pupils check them.
2. * Biologists need to be able to look at whole structures (or diagrams of whole structures) and to imagine what shape they would be if they were sliced in half.

- * Use the OHT of the root tip to show cross-wise and length-wise cuts through a biological structure.

3. Point out to the pupils what the aim (purpose) of today's lesson is.

4. Allow the pupils to work in pairs on the stereogram exercise. For each diagram they should:-

- * carefully examine the diagram
- * imagine what shape the object would be in 3-D
- * imagine cutting it through centrally from **top to bottom**
- * draw what they think one half would look like "face on" (i.e. viewed directly from the front).
- * imagine cutting it in half **across** the shape
- * draw what they think one half, face on, would look like
- * discuss their answers with their partners, noting any differences in their predictions
- * go and locate the appropriate whole shape, handle and examine it
- * if they change their minds about the sectional shapes, they must modify their "predicted" drawings
- * check their answers by taking apart the two halves of the model for both the length-wise cut and the cross-wise cuts (please ask them to handle the models with great care, and not to make new holes when they put the two halves together again)
- * indicate (in a different colour on their drawings) any corrections that are needed

If this exercise is not finished in class, they should complete it at home, and check the models in their own time as soon as possible. However, try to control the time in class so that they spend a limited time on each shape, and get finished.

5. * Use the last 5 minutes of the lesson to discuss the problem of using terms like "top-to-bottom cut" with certain objects, as discussed in the "teacher's notes" (use the OHT of the two pencils to help you explain)
 - * Advise that the terms "length-wise" and "cross-wise" are used rather, so that orientation is immaterial.
6. * Discuss the idea that longitudinal cuts can be made in many planes (e.g. back-to-back- or side-to-side) as long as they are top-to-bottom.
 - * Cross-cuts can also be made in many places on the specimen or shape.
7. * Give the pupils the Brain-teaser No. 1, and challenge them to work out the answer.
 - * Put aside a notice-board to display their answers.

TEACHER'S NOTES

(Lesson 2)

The question of orientation

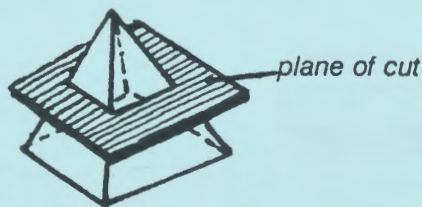
*The question of orientation of an object and whether or not it affects where a section is cut, is an interesting one. Use the OHT of the two pencils as an example. If one is making a top-to-bottom cut, does it matter which way the pencil is lying? Point out that it would be better to use a term like "length-wise cut", as then it will not matter how the pencil is lying, because the cut will always be along the **length** of the pencil.*

This becomes particularly important in the next lesson where you are dealing with sections of living things.

Where to cut the sections

CROSS-CUTS

*It is important to point out that a cross-cut could be made in many different places on an object or specimen, as long as it is cut **across** the specimen. In the "sectioning geometric shapes" exercise, for example, the size of the cross-cut of the pyramid will depend on how close to the top of the pyramid the cut is made*



Cut surface viewed "face on"



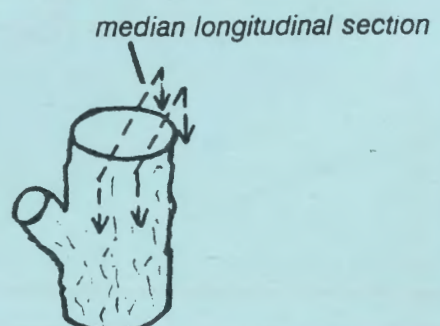
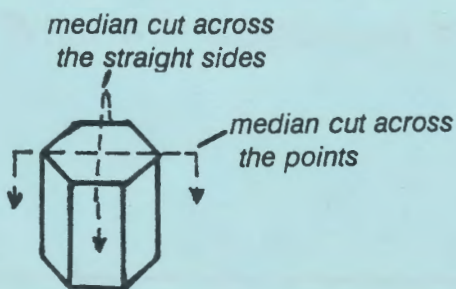
higher cut

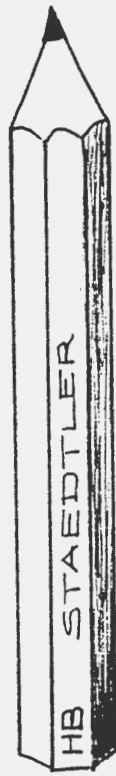


lower cut

LONGITUDINAL CUTS

*In the case of longitudinal cuts, a similar statement can be made. There are many planes in which a longitudinal cut can be made, as long as it is "top-to-bottom" or "nose-to-tail". In biology the type of longitudinal section the pupils are likely to encounter is the **MEDIAN LONGITUDINAL SECTION** - made through the centre of the specimen rather than off to the side.*

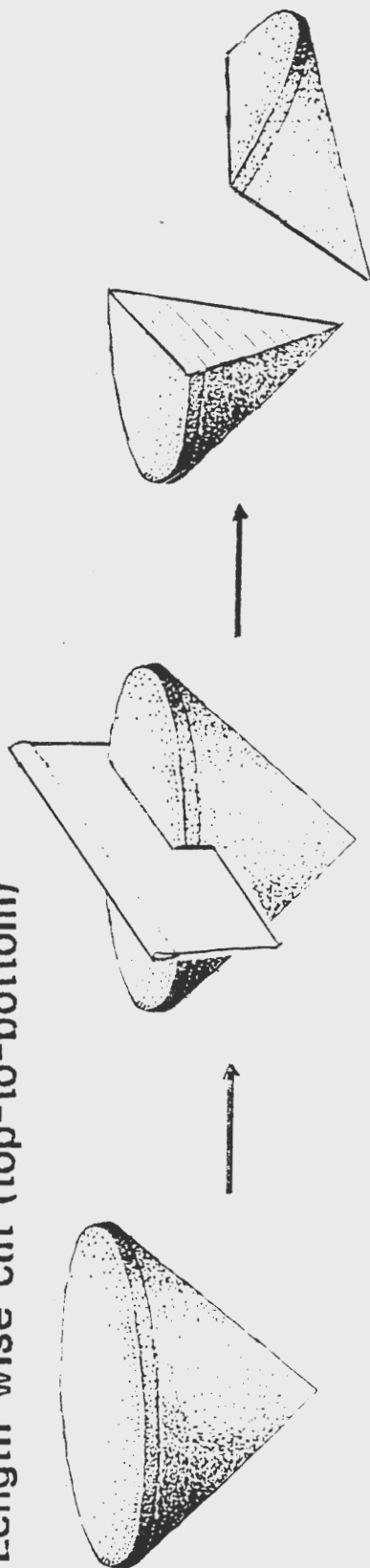




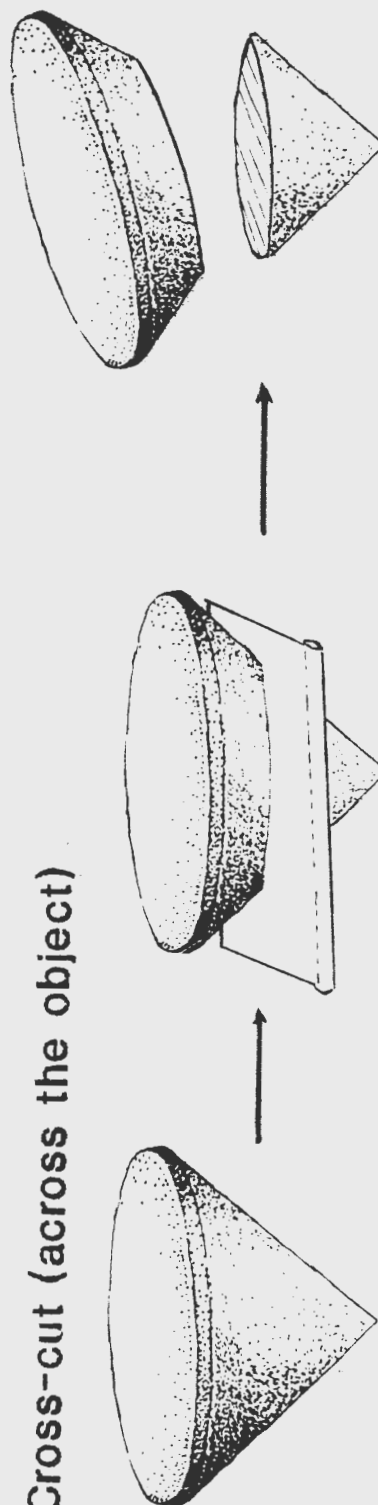
DOES ORIENTATION MATTER?

1. What will a length-wise cut (from top-to-bottom) look like for each of the pencils?
2. What will a cross-cut look like for each of the pencils?

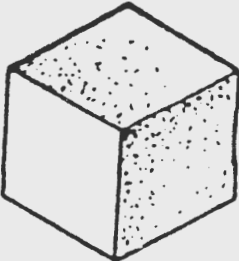

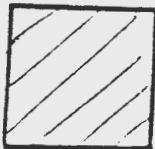
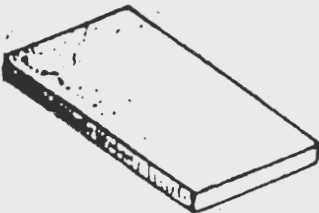




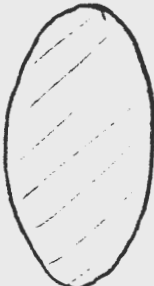
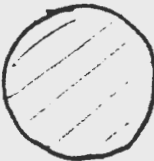

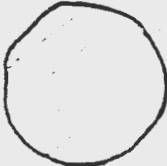
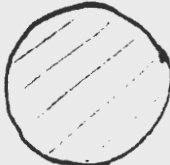






Length-wise cut (top-to-bottom)

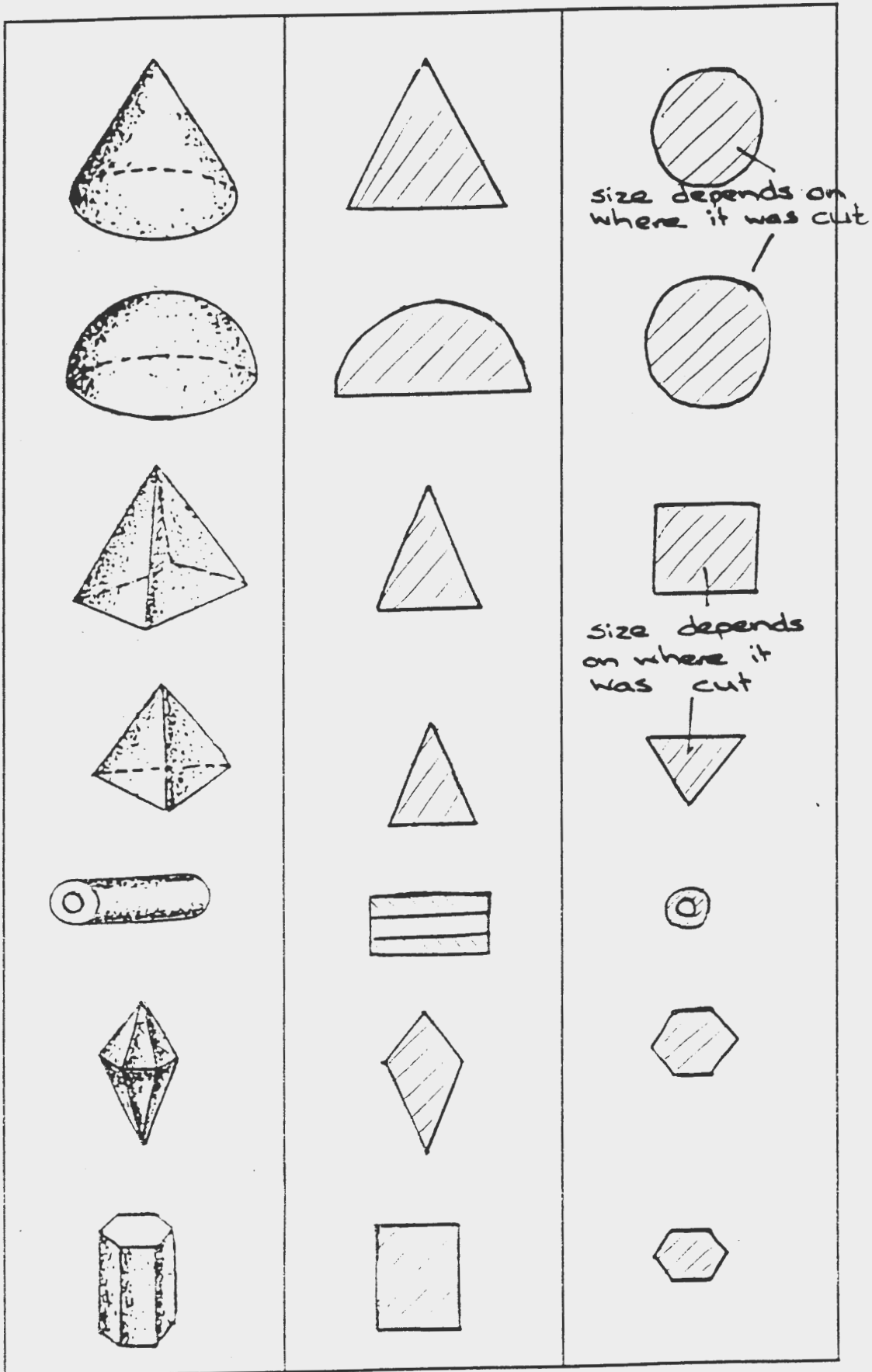


Cross-cut (across the object)



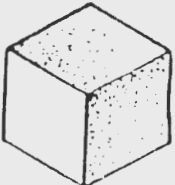
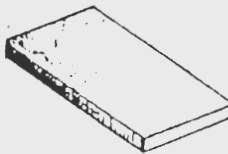




Sectioning geometric shapes

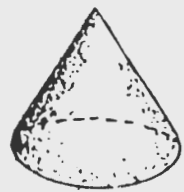
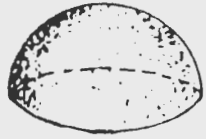
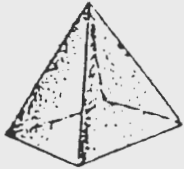
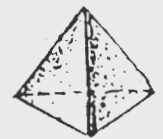
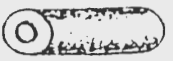


3-D shape	length-wise cut	cross-cut
	<p>Take careful note of shapes and sizes</p> 	
	 <p>or</p> 	
		
		
	<p>This could be the other way around. It depends on your interpretation of <u>lengthwise</u></p> 	
		



Sectioning geometric shapes

1. Try to imagine the geometric shape shown in each diagram as it would look in 3-D.
2. Imagine slicing it in half LENGTH-WISE, and viewing the cut half "face-on". Draw, in the first column, what you think it would look like.
3. Now imagine cutting a CROSS-CUT through the 3-D shape, and viewing it "face-on". Draw what you think it would look like, in the second column.

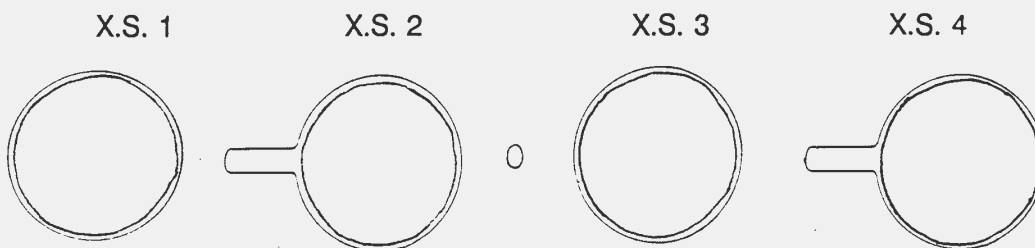
3-D shape	length-wise cut	cross-cut
		
		
		
		
		
		

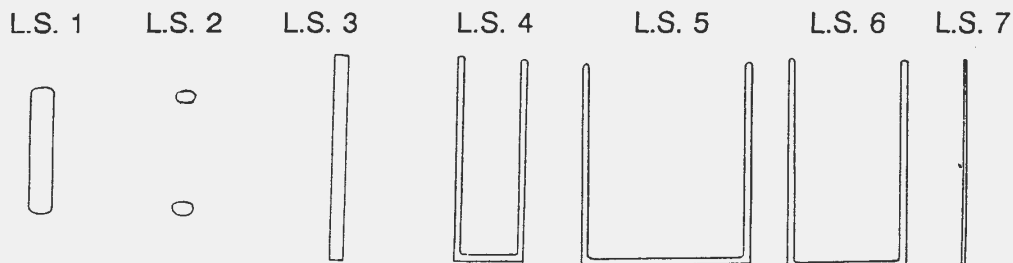
Thinking in 3-D: Brain-teaser No. 1 (Identification of an everyday object)

A common everyday object familiar to you is used in this exercise. See if you are able to identify what it is from the clues provided.

A series of cross-sections have been cut through the object, starting near the top of the object, and moving towards the bottom. The cross-sections, when viewed face-on, look like this



Now a series of longitudinal sections are cut through the object, starting on the left, and moving across to the right. These sections are shown below.



See if you can work out what the object is, by using the sections provided to build a 3-D image in your mind. Sketch the object, and show by means of dotted lines where each of the sections shown were cut through it.

Teacher's comments on lesson

School: _____ Teacher: _____ Lesson No. _____

Time spent on lesson: _____

How lesson was taught: Please mention briefly how the lesson was dealt with e.g. teacher demonstration, whole class exercise, small group work, individual pupil work etc.

When exercises were done: Please mention (for each exercise) if these were done in class, or for homework.

Checking of answers: Please indicate whether the pupils' answers were checked, and if so, how this was done (e.g. answers displayed on a board, and pupils given 5 minutes at start of lesson to check their homework, or teacher went over answers in class at the end of the lesson etc.)

COMMENTS

Problems experienced by teacher:

Problems experienced by the pupils:

General comments on the lesson:

LESSON 3

(Biological sections and drawing skills)

Recommended time

A double period

Purposes of the lesson

1. To help pupils to improve their powers of observation and their drawing skills.
2. To teach the concept of biological sections (longitudinal- and cross-sections).
3. To allow the pupils to practise and develop the skill of predicting sectional shapes, using living things.

Requirements for lesson

1. Overhead transparencies:
 - Blue-breasted Schlemptygump.
 - cutting sections of a plant stem
 - caterpillars
 - cutting sections (bread and flower)
 - cutting through biological structures (answers)
2. Handouts: (1 per pupil)
 - cutting through biological structures
3. Per 4 pupils, 1 paper bag containing:-
 - 2 bananas
 - 2 mushrooms
 - a serrated knife
 - 2 paper towels

Points to make in the lesson

1. Explain that biology pupils often complain that their drawings are not very good "because they are not artists". Point out that this is just an excuse, and that **anyone** can do good drawings if they **observe accurately** and then **draw what they see**.

2. Use the simple Blue-breasted Schlemptygump exercise on drawing (see "teacher's notes") to help pupils to develop the skills of accurate observation and drawing. This should not take more than 10 minutes.
3. * Two common types of cuts that are made through living things are length-wise cuts (correctly called **longitudinal** cuts) and cross-wise cuts (correctly called **transverse** or **cross** cuts).
 - * Use a ruler as a "knife" and a pupil as a "specimen", and indicate where you would cut to get a longitudinal cut, and where you would cut to get a cross cut.
4. Explain the difference between a **cut** and a **section** (see "teacher's notes"). Use OHT of "cutting a section through a plant stem" to illustrate a **longitudinal section** and a **cross-section**. Follow up with the OHT of the slice-of-bread analogy.
5. Use the caterpillar OHT to discuss the question of orientation (see "teacher's notes").
6. Use the OHT to introduce the terms
 - * dorsal / ventral (top / bottom) for plants
 - * anterior / posterior (front / back) for lower animals.
 - * dorsal / ventral (top / bottom) for lower animals
7. Emphasise the importance of pupils understanding the relationship between sections and the wholes from which they are cut, and being able to predict what shape sections will be.
8. * Point out that the following exercise is to help them develop this skill of predicting sectional shapes. Remind them of the importance of accurate observation and drawing .
 - * Allow pupils to work in groups of 4 on the banana and mushroom exercise (see "teacher's notes").
9. To consolidate the lesson, emphasise the importance of biology pupils getting to know not only outline shapes of living things, but also what they look like inside.
10. * Give the pupils the exercise on "cutting longitudinal- and cross-cuts through biological structures" to do for homework.
 - * Ask them to draw a solid line (using a coloured pen) to show where they would cut through each structure to produce a longitudinal cut and a dotted line to show where they would cut to produce a **cross-cut**.
 - * Briefly go over the answers with them at the start of the next lesson, or put up the answers on a display board, and ensure that all pupils check them.

Encourage the pupils to look more carefully at the things they eat (fruit, vegetables, meat, bones, fish) and to try to imagine them as 3-D specimens, and to think of them in terms of what cross-cuts and longitudinal-cuts would look like.

TEACHER'S NOTES

(Lesson 3)

Drawing exercise

Step 1: Tell the pupils that you are going to show them a picture for 20 seconds, after which they will be asked to do a drawing which looks AS MUCH LIKE THE ORIGINAL AS POSSIBLE. Whilst they are looking at the drawing they must not have their pencils in their hands - they must just look very carefully.

Step 2: Show them the overhead transparency of the Blue-breasted Schlemptygump for a period of 20 seconds.

Step 3: Switch off the overhead projector, and allow the pupils to do the drawing.

Step 4: When they have finished, allow the pupils to look at the OHT again. Ask them to use a different colour pen or pencil to alter their drawing so that it looks more like the original.

Step 5: Elicit from the pupils what points they think are important if one wants a drawing to look as much like the original as possible. They should be able to tell you the importance of the following points. As a pupil mentions each one list it on the chalk-board, and show examples on the Blue-breasted Schlemptygump OHT which illustrate the point.

SHAPE: Point out the angular shape of the jaw, the bulbous shape of the nose, the squared edges of the "feathers" on the head. If these are not depicted accurately the whole drawing looks wrong.

RELATIVE SIZE: Point out that the head is at least half as big as the body, and the body is about twice as long as it is high. If relative sizes are wrong, the picture does not look right.

POSITION OF STRUCTURES: Point out the position of the tail halfway down the back, the spacing of the "feathers" on the top and back of the head, and the position of the feet relative to the breast. If these are not in the correct place, the drawing will not look like the original.

NUMBER OF STRUCTURES: Point out the number of toes on front and back legs, the number of "feathers" etc. Mention that in biology, a specific number of some feature is often a species-specific characteristic - e.g. *Pinus sylvestris* has just two needles per dwarf shoot, and if they draw a specimen of this species of pine with fewer or more needles (because they haven't looked carefully) their drawings will be scientifically inaccurate.

Step 6: Relate the importance of each of these points to making accurate drawings of anything they draw.

NB 1: It is realised that this exercise does not only measure the pupils' ability to observe and draw accurately, but also a degree of memorisation. However, it does serve to make the pupils aware of what they need to consider in order to do an accurate drawing, and its use is therefore justified.

NB 2: It might be a good idea to follow this exercise with instructions about drawing techniques and the rules you expect them to use when drawing for you in biology.

NB 3: Observational skills can be followed up for several lessons by asking the pupils appropriate questions which will make them more observant. For example:

- * What colour are the curtains in the school hall?
- * How many steps are there in front of the entrance of the school?
- * What animal is shown on the poster on the back wall? (don't let them turn round to check - the poster has been there for weeks).

Games such as these can help the pupils to become better observers.

The difference between a "cut" and a "section"

It is important to differentiate between these two terms.

A CUT: *Whether this is a longitudinal or transverse cut, it involves only a single cut being made through the organism. You could draw this by means of a 3-D picture, as the structure can be seen in 3-D. You could use the OHT from the previous lesson (length-wise and cross-wise cuts) to illustrate "cuts".*

A SECTION: *This would involve two cuts being made to produce a thin slice of the specimen. Use the analogy of a slice being cut out of a loaf of bread (illustrate this with the OHT). If drawn, the drawing would only be in 2-D, as the slice is so thin that you would not see it in 3-D. The reason that the slice is so thin is that it must be thin enough for the light from the microscope to shine right through it, so that it is visible to the viewer. In any case, sections are usually turned and viewed "face-on".*

Position of sections

*Remind the pupils that the **orientation** of the specimen is not important. Rather the direction of the section is. Use the OHT of the two caterpillars to show that a **longitudinal section (L.S.)** will always be a LENGTHWISE cut or NOSE-TO-TAIL in the case of an animal. They will not have a circular L.S. if the caterpillar is climbing up the wall, and a long sausage-shaped L.S. if the caterpillar is walking across the floor.*

*The most common type of L.S. that pupils are likely to encounter is the **median** L.S. made through the centre of the specimen rather than off to the side. In the case of animals the cut will be between the eyes along the line of symmetry which will divide the body into two mirror-image halves.*

*A **cross section (X.S.)** or **transverse section (T.S.)** will be cut across the body at right-angles to the longitudinal section. However, it could be cut across the body at many different levels.*

Get the pupils to tell you where a L.S. and a X.S. through a bi-ped (like a human) would be cut, as well as through a quadruped (like a dog). (Get them to demonstrate on a pupil, using a ruler as a "knife").

Terminology

Introduce the pupils to the terms

- * anterior ("front" or "head" end)
- * posterior ("back" or "tail" end)

- * dorsal ("top" in invertebrates and most vertebrates, but the "back" in man as he walks upright)
- * ventral ("lower side" in invertebrates and most vertebrates, but the front of man because of his posture).

The sectioning exercise

Aim: To allow the pupils to handle an object, observe it accurately, predict (using a diagram) what it will look like if cut through in a certain direction, and then to check their predictions by making an actual cut and looking to see what it really looks like.

1. In each case get the pupils to examine carefully the structure to be sectioned.
2. Then tell them to draw what they think it would look like if cut in a particular direction (e.g. across or lengthwise)
3. Then allow them actually make the cut and physically check their drawings (and correct them)
4. Follow steps 1 to 3 for each of the following examples:
 - * Start with a cross-cut through a banana.
 - * Then ask them to partially peel the banana, and draw what a cross-cut would look like.



- * Finally ask them to predict what a lengthwise cut would look like, using the second banana from their packet.

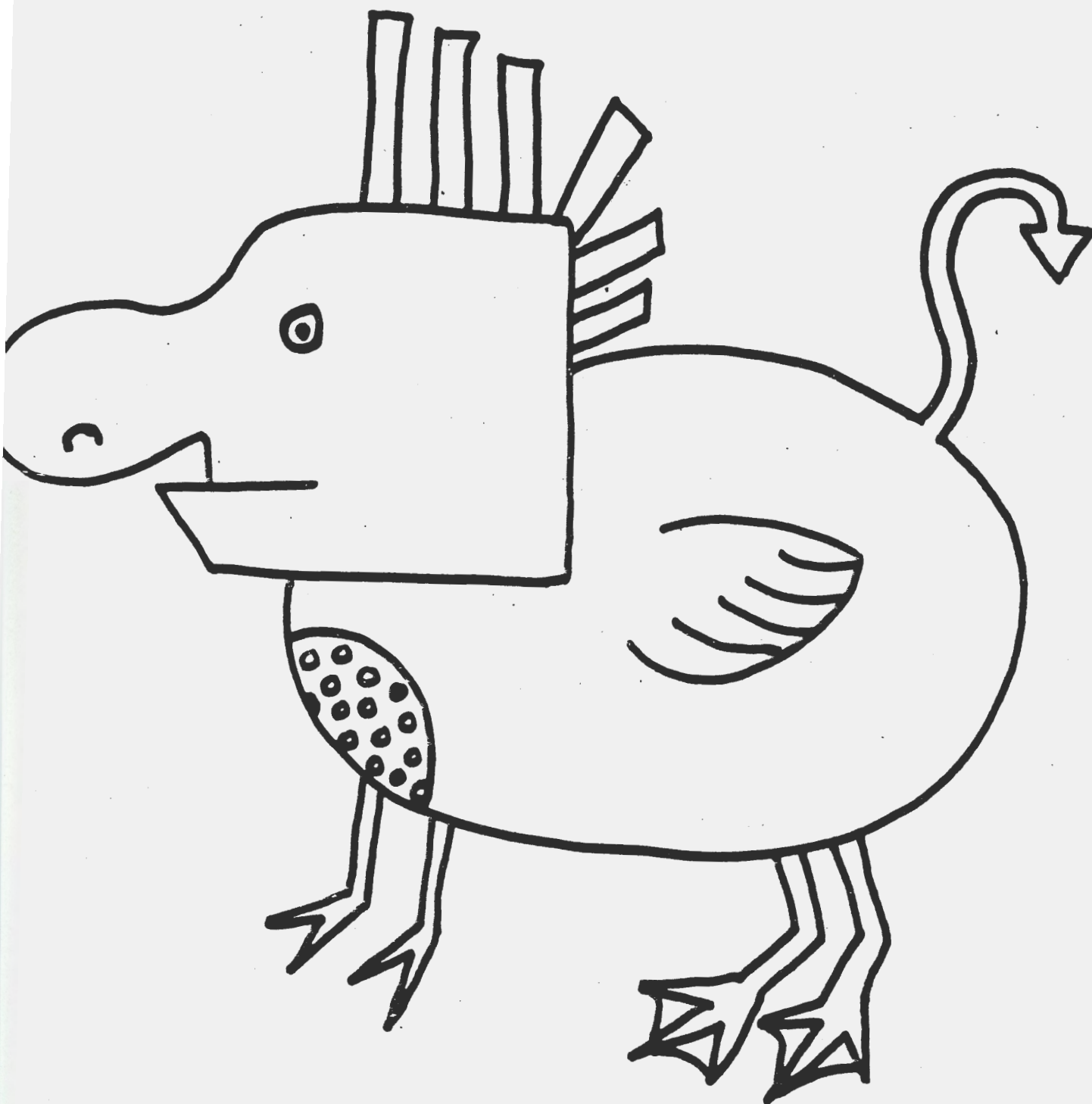
Bananas are excellent specimens to use, as one seldom sees the "pips" unless the banana is cut lengthwise. Furthermore, many children have never seen a banana divided into its 3 natural segments. Demonstrate how this is done, and see if they can predict what a cut through the divided area would look like. Finally, when the task is complete, the "specimens" may be eaten.

- * Continue with cross-cuts of a mushroom at three different levels.
- * Once the pupils have learned about the structure of the mushroom from these cuts, use the second mushroom to do a longitudinal cut.

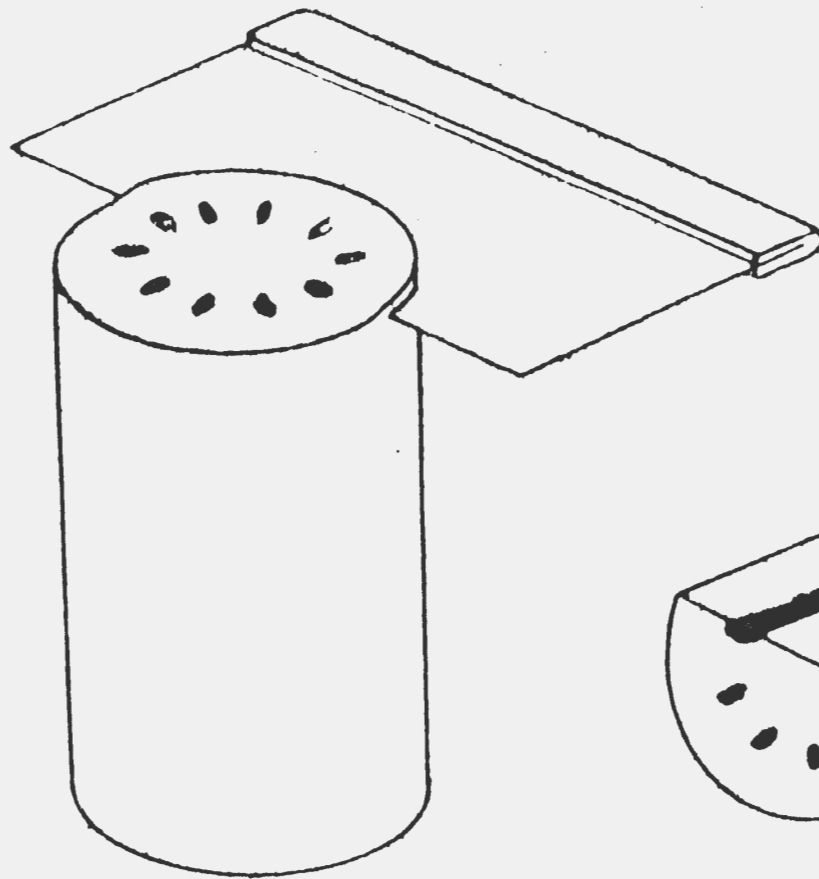


5. Let the pupils work on one paper towel, and use the second one to clean up. Use the paper bag as a rubbish bin.

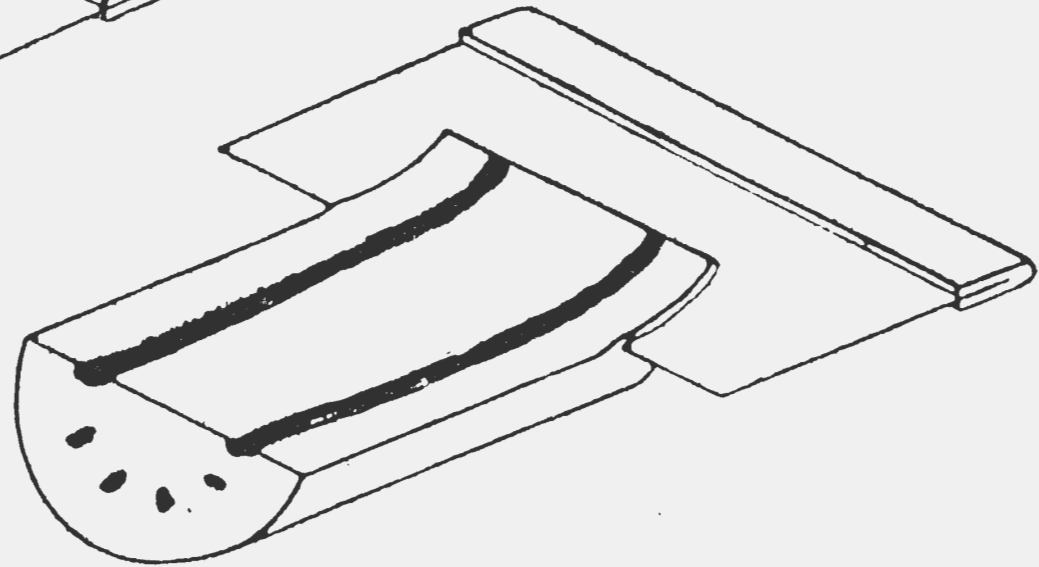
The importance of this exercise is to use objects which the pupils can actually cut in order to check their predictions. One can use other fruits (e.g. oranges, green peppers etc.)



BLUE-BREASTED SCHLEPTYGUMP

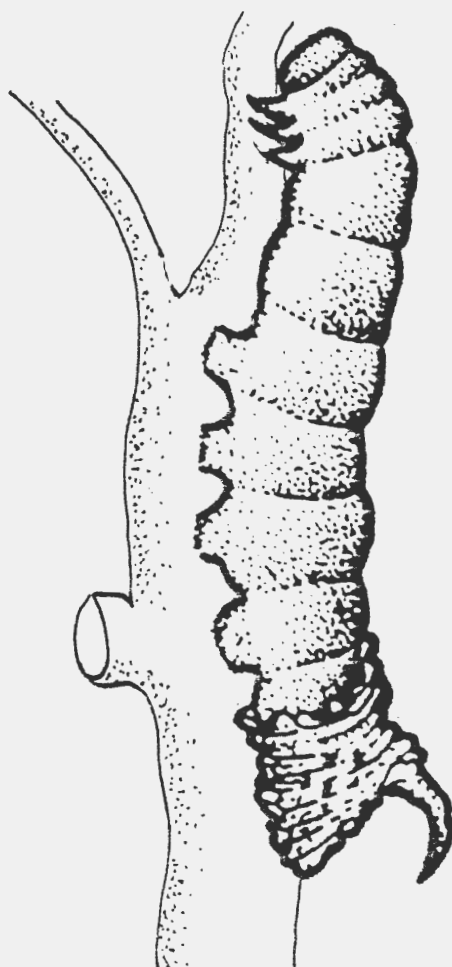
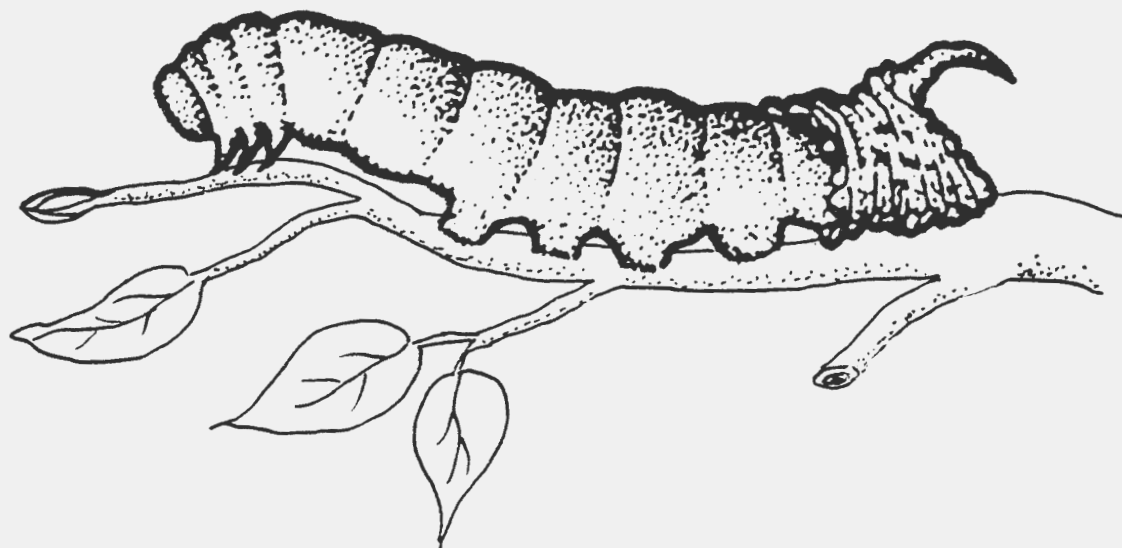


transverse
section



longitudinal
section

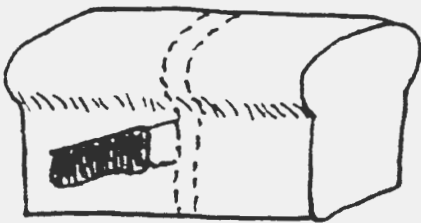
Cutting sections of a plant stem



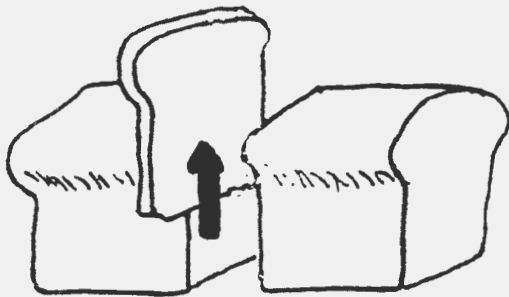
Biological sections (a comparison)

Cutting a slice of bread

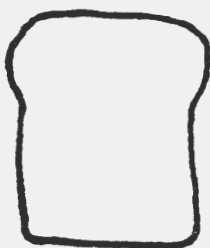
Cutting a slice



Removing slice

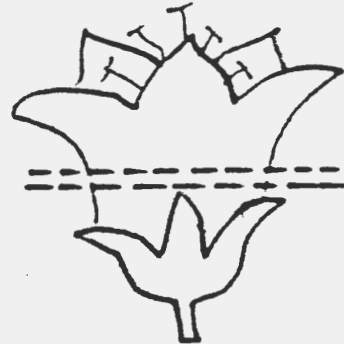


Slice turned & viewed face-on

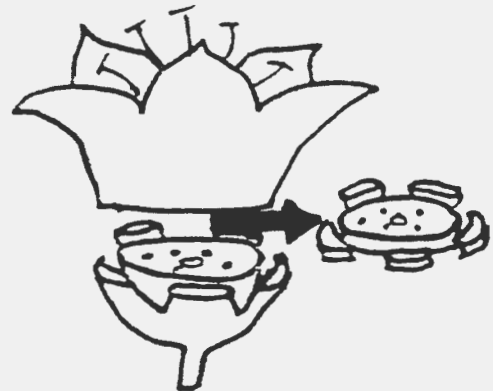


Cutting a biological section

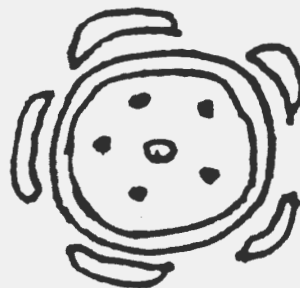
Cutting a section



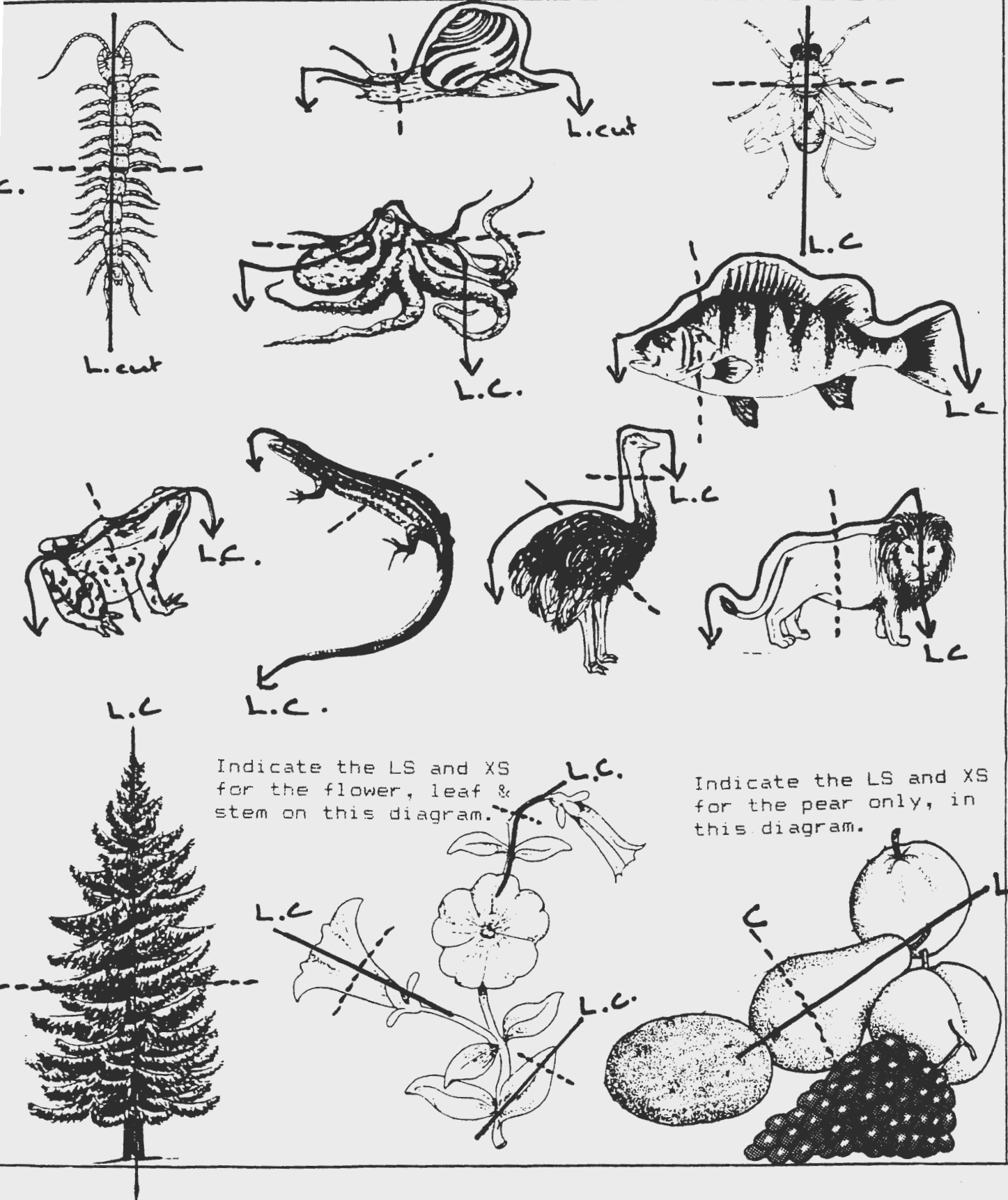
Removing section



Section turned & viewed face-on



— = longitudinal cut
 --- = cross cut.



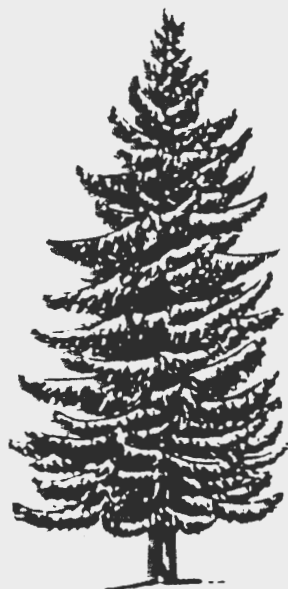
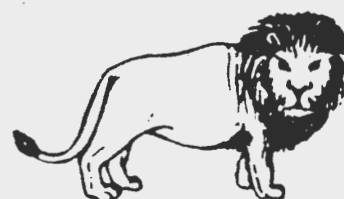
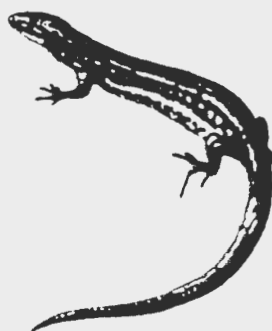
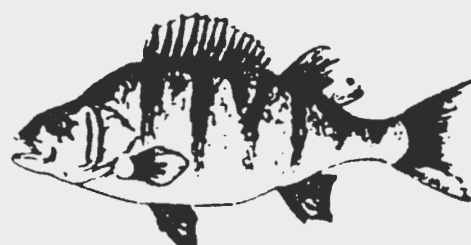
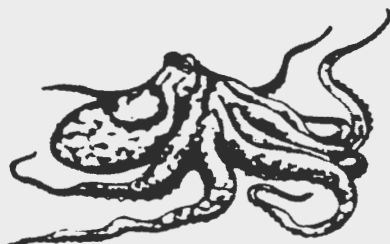
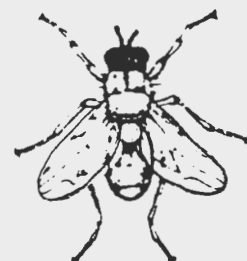
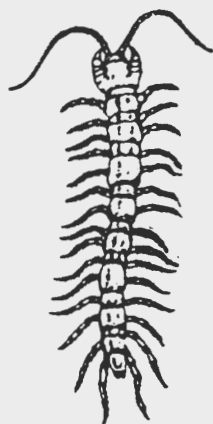
Indicate the LS and XS for the flower, leaf & stem on this diagram.

Indicate the LS and XS for the pear only, in this diagram.

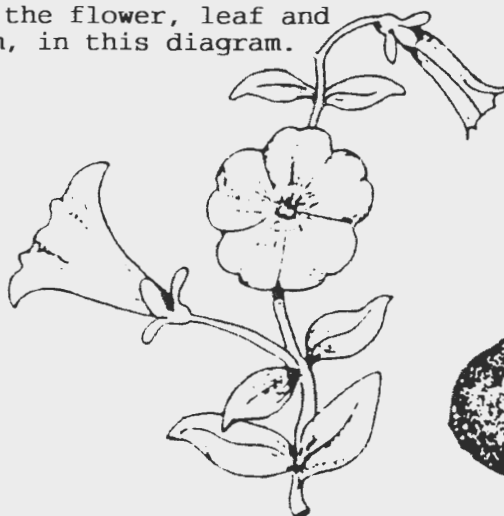
MAKING LONGITUDINAL-CUTS AND CROSS-CUTS THROUGH BIOLOGICAL STRUCTURES

1. By drawing a solid line, indicate where you would cut through each of the biological structures shown below, if you wanted to make a LONGITUDINAL CUT (or a LONGITUDINAL-SECTION).
2. Then, by drawing a dotted line, show where you would cut through each structure if you wanted to make a CROSS-CUT (or a CROSS-SECTION).

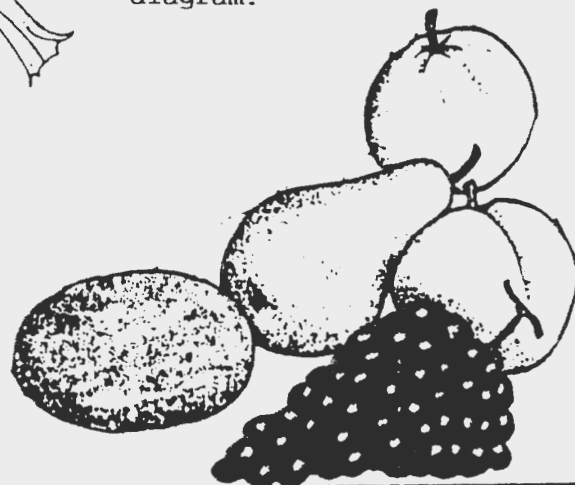
NB: Some of them are sneaky, so you will have to think!



Indicate the L.S. and X.S.
for the flower, leaf and
stem, in this diagram.



Indicate the L.S. and X.S.
for the pear only, in this
diagram.



Teacher's comments on lesson

School: _____ Teacher: _____ Lesson No. _____

Time spent on lesson: _____

How lesson was taught: Please mention briefly how the lesson was dealt with e.g. teacher demonstration, whole class exercise, small group work, individual pupil work etc.

When exercises were done: Please mention (for each exercise) if these were done in class, or for homework.

Checking of answers: Please indicate whether the pupils' answers were checked, and if so, how this was done (e.g. answers displayed on a board, and pupils given 5 minutes at start of lesson to check their homework, or teacher went over answers in class at the end of the lesson etc.)

COMMENTS

Problems experienced by teacher:

Problems experienced by the pupils:

General comments on the lesson:

LESSON 4

(Revision of the cell concept, and looking at size)

Recommended time

A single lesson

Purpose of lesson

1. To emphasise that living organisms are made up of SYSTEMS, each adapted for a specific function.
2. To explain that all systems are made of building blocks called cells.
3. To emphasise that while all cells have a certain basic structure, they are structurally modified to perform particular functions.
4. To teach the units of measurement for cells (micrometers), and to give the pupils exercises to help them visualise the size of cells.

Requirements for lesson

1. Overhead transparencies
 - concrete frame of building
 - comparison of building and vertebrate
 - different animal cells (with sizes)
 - pin-head and animal cells
 - animal-cells showing structural adaptations
2. Handouts (1 per pupil): Exercise on size
3. Box of pins (1 per pupil)
4. Answer sheets (exercise on size)

Points to make to the pupils

1. Ensure that the answers to the exercises done in the previous lesson are checked.
2. Using the model of a large department store, and a question-and-answer strategy, develop the concept of the building being made up of several systems, each to perform a particular FUNCTION (see "teachers' notes"). NB: Use the OHT of the concrete framework to get the discussion going.
3. Develop the analogy of living organisms (e.g. a plant or the human body) having systems to perform particular functions. (Use the OHT provided to summarise the comparison).

4. Develop the idea of using "building blocks" to build a department store. Emphasise that the building materials differ depending on the function they have to perform (see "teachers' notes").
5. Revise the idea of cells as the building blocks of living things. However, point out that not all cells have the same basic structure (which they learned about in Std 7). Cells are adapted so that they are structurally suited to do the job they have to do (show both OHTs of cell types).
6. Explain that many pupils struggle to understand the size of cells, and the organelles inside them. They often get confused by the nucleus of an atom (in science) and the nucleus of the cell.
7. Use the rest of the lesson to help the pupils develop an understanding of size, and how atoms relate to cells.
8. Explain that the unit used to measure the cell is the micrometer (μm).
$$1\text{mm} = 1000\mu\text{m}.$$
9. If a pinhead is 1mm across, that will be $1000\mu\text{m}$. Use the OHT provided, and elicit from the pupils the answers to the questions on it.
10. Let pupils do the exercise on cell size, if there is time. If not, give it to them for homework. (Don't forget to follow up to see that they can all do the calculations).

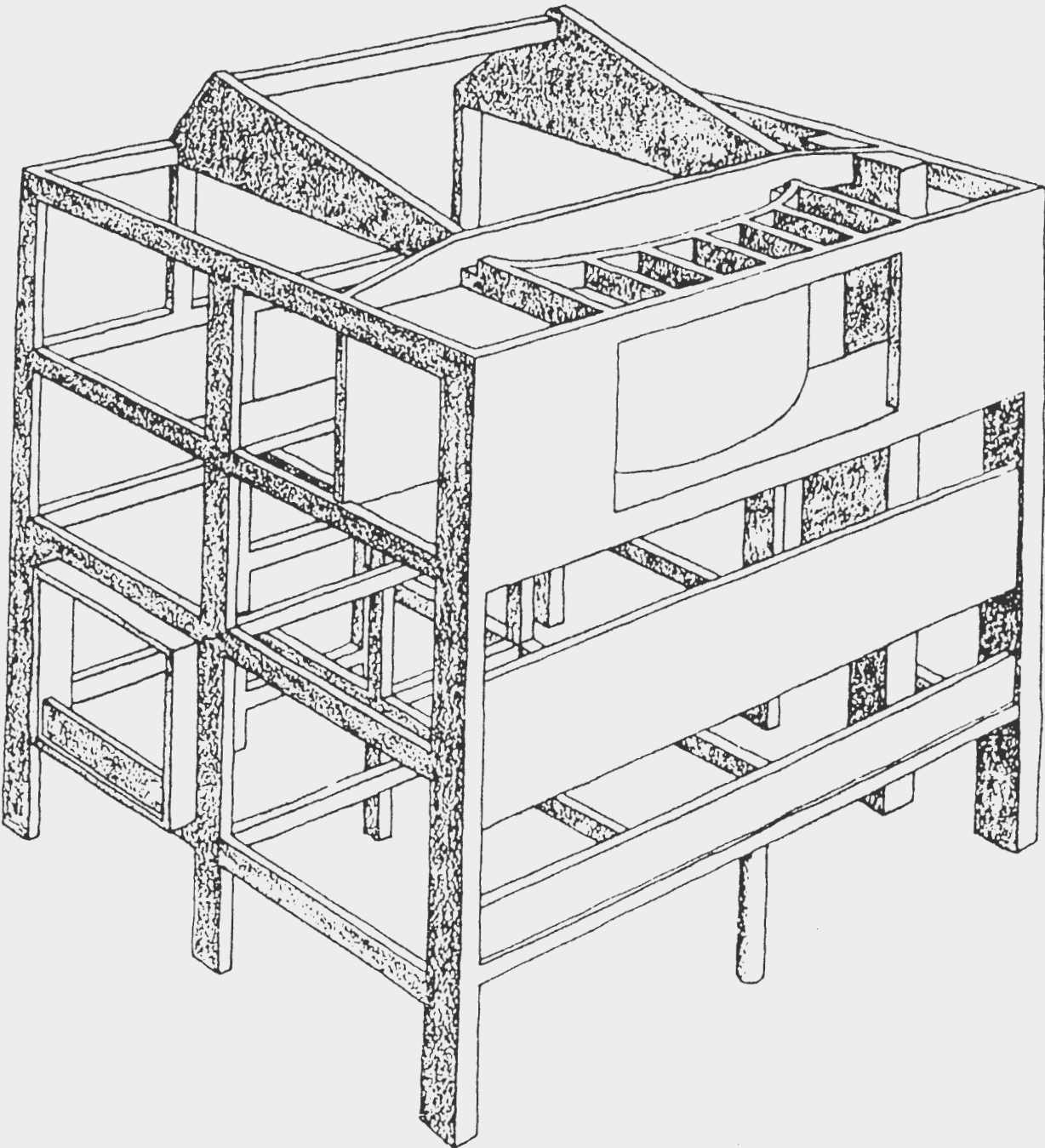
TEACHER'S NOTES (Lesson 4)

The building analogy

1. *Ask the pupils if they have watched a large building being erected. What gets built first? Use the OHT of the concrete frame-work to elicit the idea of a strong **support** system.*
2. *Ask how everything inside the building will be **protected**, and elicit from the pupils the use of walls, windows, roofs etc.*
3. *How will people who use the building, as well as the necessities they require for the activities in the building, be **transported** to where they are needed? Elicit that lifts, stairs, escalators, passages, pipes, air conduits, electrical wiring etc. are used to transport them. Discuss examples of transport of people, water, electricity, fresh air, etc.*
4. *How will **waste-matter be removed**? Elicit that drains, sewers, refuse removal by cleaners etc. will be used.*
5. *How will **energy be supplied**? Discuss electricity (for heat, light etc.) or coal for the boiler system.*
6. *How will people in different parts of the building **communicate**? They could use telephones or an inter-com system.*
7. *Develop the idea of using particular **SYSTEMS** to perform particular functions.*
8. *Develop the idea that in living organisms (e.g. plants and animals) a similar set-up exists. Certain jobs have to be done (all of those highlighted in the "building" analogy used above, for example). Each of these tasks will be performed by a certain system in living organisms.*
9. *Use the OHT to develop the comparison using **FUNCTION** as the basis for the comparison of systems.*

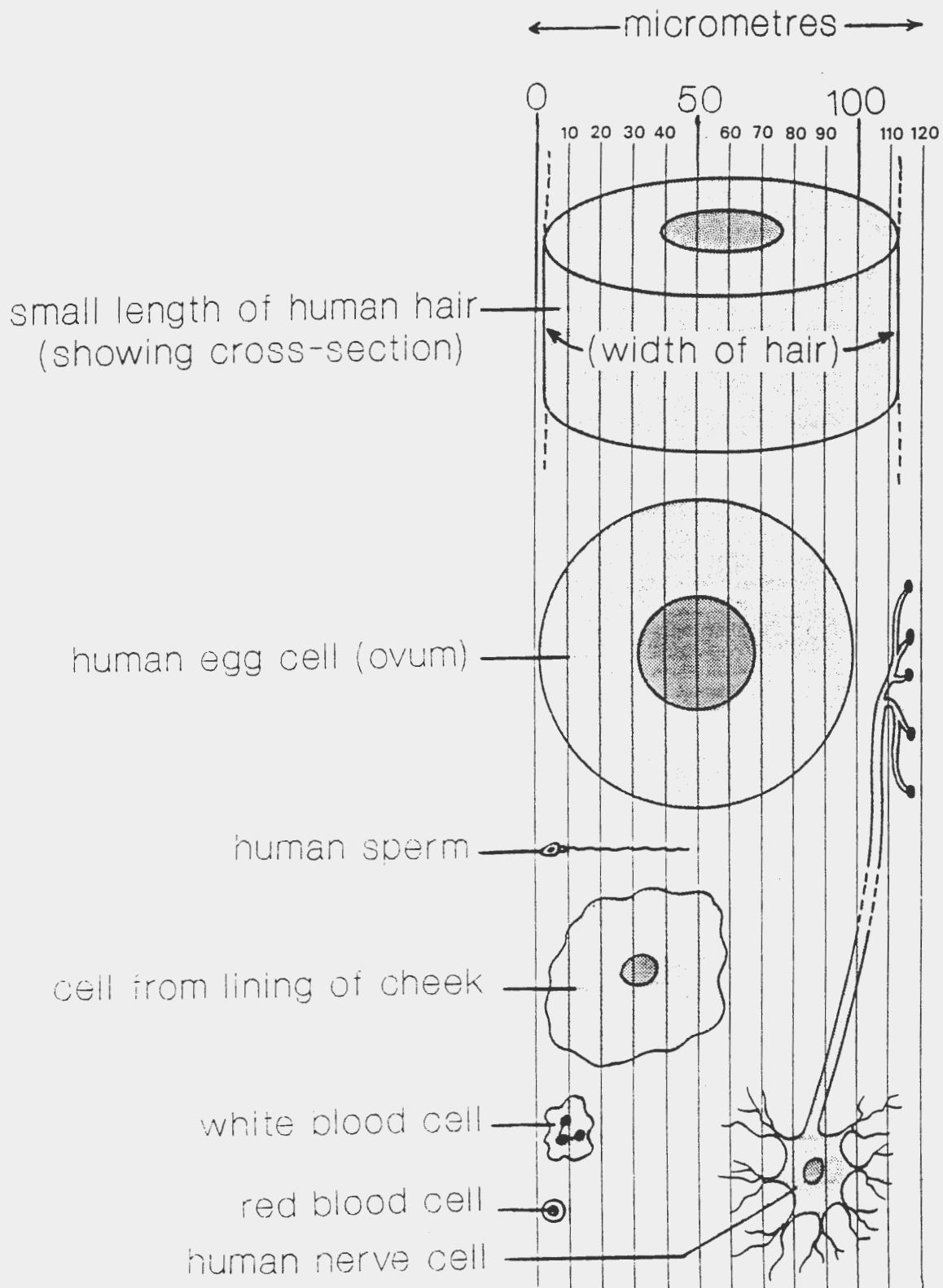
Building blocks

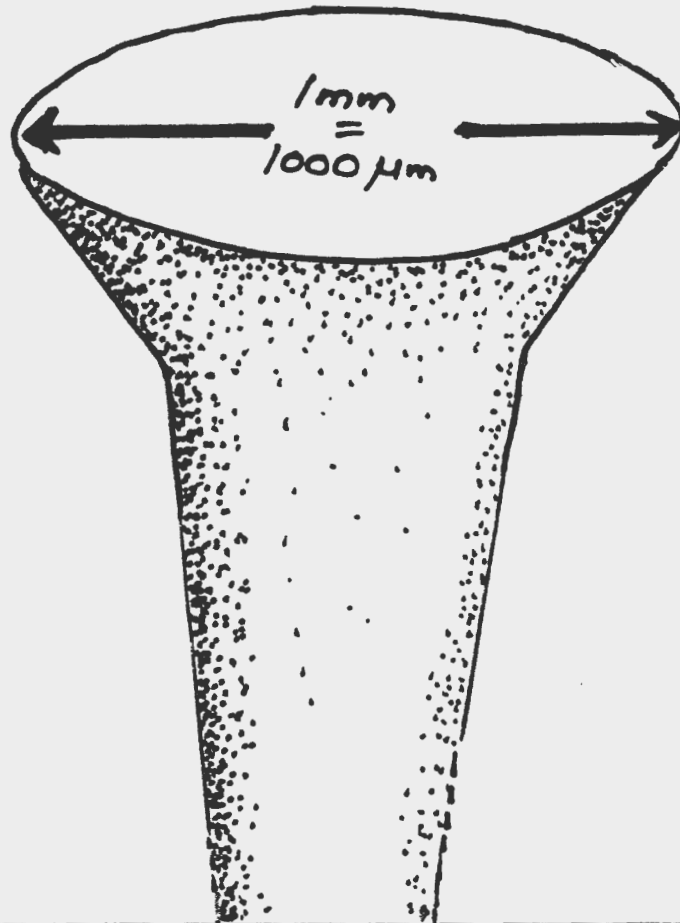
1. *In the building, a variety of building materials are used to make the necessary systems.*
2. *Start with the idea of bricks as the building units (blocks) of walls. Point out that bricks, however, would be inappropriate for making drainpipes or windows. So building blocks (units) need to be structurally adapted so that they will perform the job for which they are required (e.g. sheets of glass for windows, so that they will let in the light, as well as protect the inside of the building).*
3. *The same is true of plants and animals. All systems are made up of building blocks, which have the same basic components learned about in Std 7. But all cells will be structurally adapted so that they can perform the jobs they have to do.*
4. *Show the OHT of different cell types, to give an idea of the ranges of shapes and sizes.*



Function	Building	Animal (vertebrate)
strength/support	concrete framework	skeleton
protection	walls & roof (brick, glass, wood, tiles)	skin, hair, nails
transport	lift, stairs, pipes passages	respiratory and blood systems
raw materials in	deliveries, water electricity	digestive system respiratory system
waste products out	rubbish removal, & sewerage system	excretory system (bowels/kidnies)
message system	telephone, intercom,	nervous system
energy production	heating system, lights	respiratory system

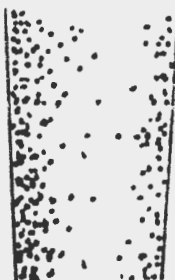
A comparison of the size of human cells to the thickness of a human hair

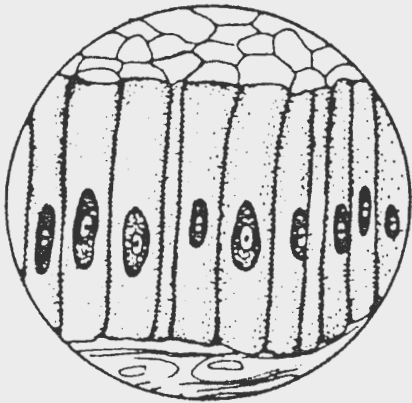




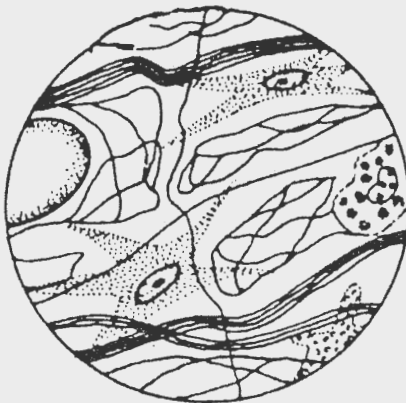
How many cells would fit next to each other across the diameter of a pin-head?

1. single-celled bacteria $1\text{ }\mu\text{m}$ long?
2. red blood cells?
3. white blood cells?
4. cells from the lining of the cheek?
5. human sperm cells (head to tail)?
6. human egg cells?

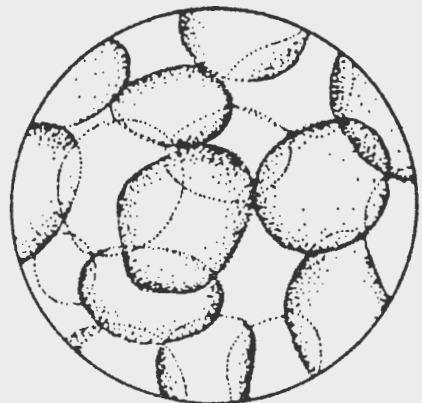




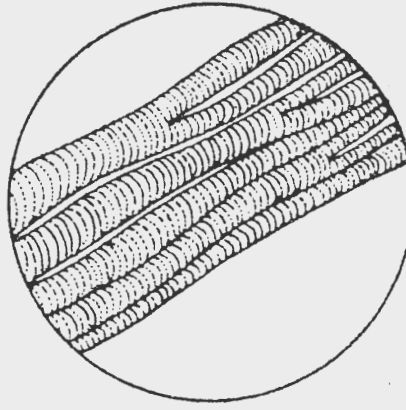
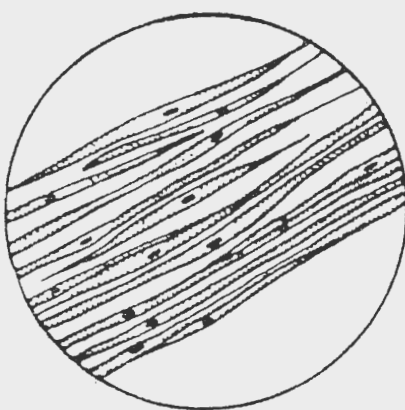
Epithelial tissue
(intestine lining)



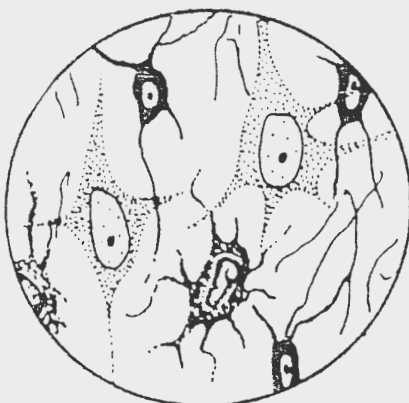
Connective tissue



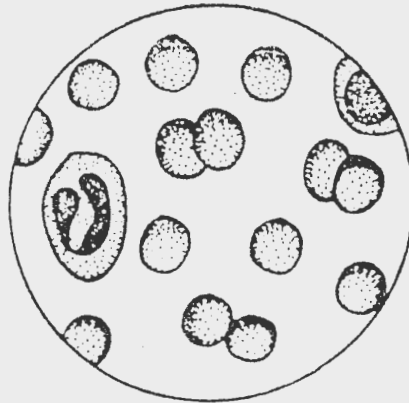
Connective tissue
(adipose)



Muscle tissue



Nerve tissue



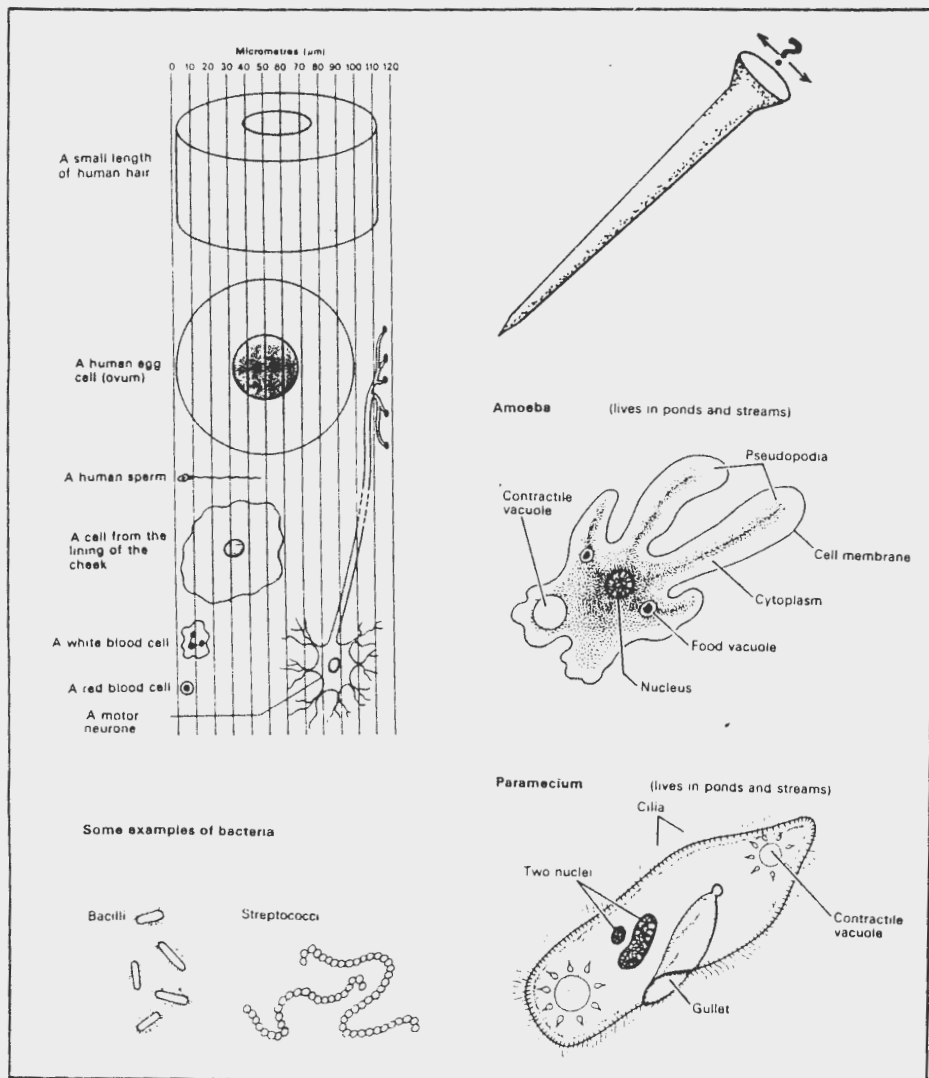
Blood tissue

An exercise on size

From the information provided on this page, answer the questions asked, and complete the table provided below.

Remember that $1\text{mm} = 1000\mu\text{m}$ and that the diameter of a pinhead = 1mm

NB: the diagrams below are not all drawn to scale



How many strands of hair would fit side-by-side across the diameter of the pinhead? Show your calculations.

Complete the following table, to show the size of each of the cells mentioned, and how many of each would fit next to each other across the head of a pin.

	diameter or length	no. across pinhead
bacteria streptococcus	$0,25\mu\text{m}$	
bacillus	$1\mu\text{m}$	
red blood cell		
white blood cell		
human sperm		
cell from cheek lining		
human egg cell		
Paramecium	$200\mu\text{m}$	
Amoeba	1mm	

Neurones (nerve cells) like the one shown need to be able to stretch from all parts of the body to the spinal cord, where they link with other nerve cells. This one could not fit on the page, so the artist has indicated, by means of broken lines, that the middle section has been removed. Human neurones (nerve cells) can be up to a metre in length!

* Bacteria (germs) are one-celled organisms. Streptococcus and bacillus are terms used to describe two shapes of bacteria.

* Paramecium and Amoeba are also one-celled organisms. They occur in pond water.

You will be learning more about all of these organisms in Std. 9.

* You can see from this exercise that cells can vary tremendously in size.

Now look at your pin. Try and imagine the size of the different cells you have considered in this exercise.

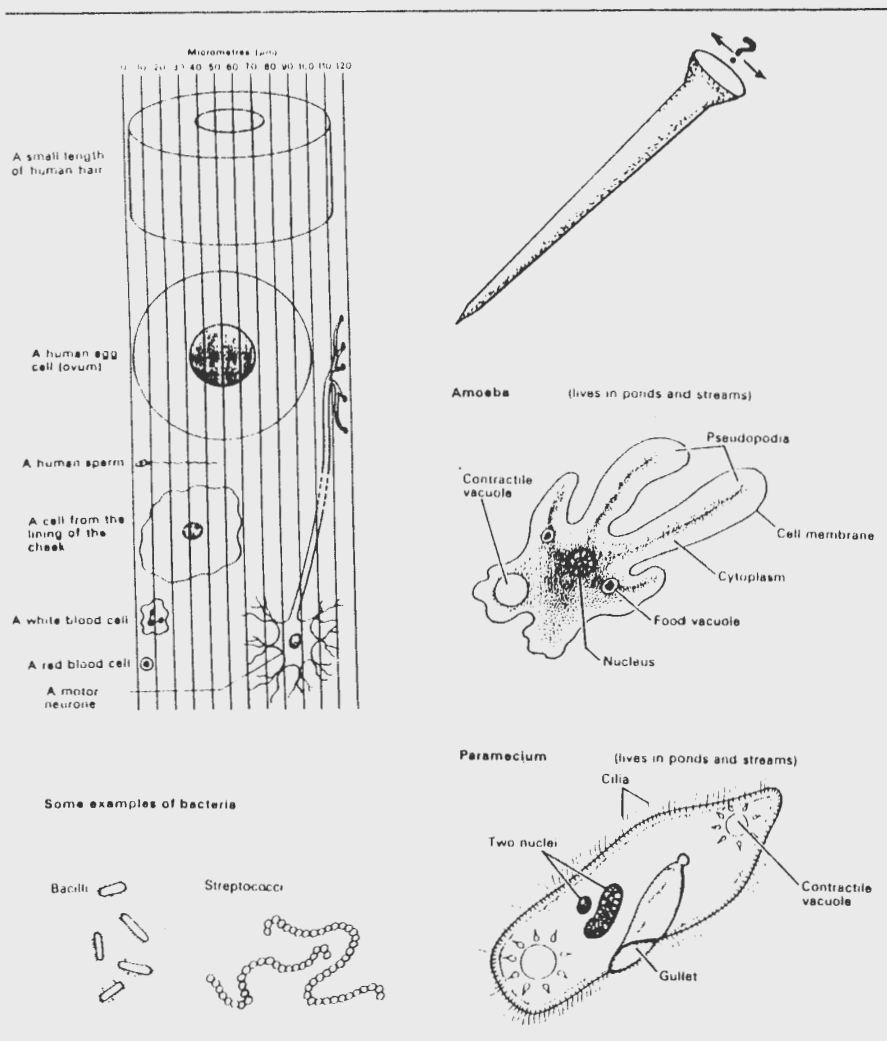
An exercise on size

Answers

From the information provided on this page, answer the questions asked, and complete the table provided below.

Remember that $1\text{mm} = 1000\mu\text{m}$ and that the diameter of a pinhead = 1mm

NB: the diagrams below are not all drawn to scale



How many strands of hair would fit side-by-side across the diameter of the pinhead? Show your calculations.

Diameter of pinhead = $1\text{mm} = 1000\mu\text{m}$
 Width of hair = $110\mu\text{m}$

$\therefore \frac{1000}{110} = 9$ hairs would fit onto pinhead

Complete the following table, to show the size of each of the cells mentioned, and how many of each would fit next to each other across the head of a pin.

	diameter or length	no. across pinhead
bacteria streptococcus	$0,25\mu\text{m}$	4000
bacillus	$1\mu\text{m}$	1000
red blood cell	$\pm 8\mu\text{m}$	± 125
white blood cell	$\pm 15\mu\text{m}$	± 67
human sperm	$\pm 5\mu\text{m}$	± 200
cell from cheek lining	$\pm 60\mu\text{m}$	± 17
human egg cell	$\pm 100\mu\text{m}$	± 10
Paramecium	$200\mu\text{m}$	± 5
Amoeba	1mm	only 1

Neurones (nerve cells) like the one shown need to be able to stretch from all parts of the body to the spinal cord, where they link with other nerve cells. This one could not fit on the page, so the artist has indicated, by means of broken lines, that the middle section has been removed. Human neurones (nerve cells) can be up to a metre in length!

* Bacteria (germs) are one-celled organisms. Streptococcus and bacillus are terms used to describe two shapes of bacteria.
 * Paramecium and Amoeba are also one-celled organisms. They occur in pond water.

You will be learning more about all of these organisms in Std. 9.

* You can see from this exercise that cells can vary tremendously in size.

Now look at your pin. Try and imagine the size of the different cells you have considered in this exercise.

Teacher's comments on lesson

School: _____ Teacher: _____ Lesson No. _____

Time spent on lesson: _____

How lesson was taught: Please mention briefly how the lesson was dealt with e.g. teacher demonstration, whole class exercise, small group work, individual pupil work etc.

When exercises were done: Please mention (for each exercise) if these were done in class, or for homework.

Checking of answers: Please indicate whether the pupils' answers were checked, and if so, how this was done (e.g. answers displayed on a board, and pupils given 5 minutes at start of lesson to check their homework, or teacher went over answers in class at the end of the lesson etc.)

COMMENTS

Problems experienced by teacher:

Problems experienced by the pupils:

General comments on the lesson:

LESSON 5

(Revision of cell structure and function)

Recommended time

A single lesson

Purpose of lesson

1. To revise the basic structure of a typical plant and a typical animal cell, including names and functions of the cell organelles covered in Std 7.
2. To ensure that the pupils are thinking of cells as 3-D structures.
3. To revise differences between plant and animal cells.
4. To emphasise the relative sizes of plant and animal cells.

Requirements for lesson

1. For the model of a plant cell
 - 3 empty 2-litre plastic coke bottles, with bases and labels removed, and cut as shown in the "teacher's notes"
 - 1 ping-pong ball with holes melted in it using a hot metal knitting needle
 - 10 jellybeans (not green) coated in clear nail polish so that the colour does not leach
 - a few marshmallow-sized blobs of green plasticine
 - a few pea-sized blobs (e.g. rascal sweets) coated with clear nail polish
 - 1 large plastic bag (230mm X 300mm)
 - 1 plastic sandwich bag (not the fold-over type) or a small round yellow balloon
 - 1 plastic teaspoon
 - 12 teaspoons gelatine
 - water, coloured with a drop of food colouring
2. Pupil exercises (1 per pupil)
 - thinking about size AGAIN
3. Answer sheet for the exercise on thinking about size AGAIN

Points to make to the pupils

1. Check the answers to exercises done in the previous lesson.

2. They now know how to use depth cues to interpret stereograms (3-D pictures) and they should understand what biological sections are. They will be using this information in the section of work to come.
3. Point out the purpose of this lesson is to revise what they already know about the basic structure and function of typical cells (done in Std 7), but with the emphasis on trying to see cells as 3-D structures
4. The structure will be revised using a demonstration by the teacher (with pupil help) during which a simple model of a plant cell will be constructed.
5. Particular attention will be paid to the relative sizes of the organelles.
6. Revise the parts of the cell by building a 3-D model as described in the "teacher's notes". Continually emphasise the correct relative sizes, structural shapes and functions of the organelles but **do not do any more detail than already covered in Std 7.**
7. Emphasise that this is a **model** so it may not always be totally realistic in terms of structure (e.g. the knot in the plastic bag which represents the vacuole) or colour (e.g. most cell parts are colourless).
8. Use the chalkboard to summarise **terminology** (organelle names) and the **function** of each organelle.
9. Revise the basic differences between plant and animal cells.
10. Give the pupils the exercise on size to start in class (if there is time). If they do not finish in class, the exercise must be completed for homework.

TEACHER'S NOTES

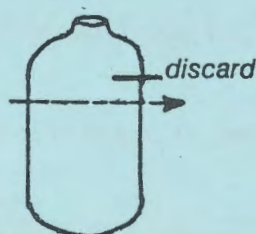
(Lesson 5)

Making a model of the plant cell

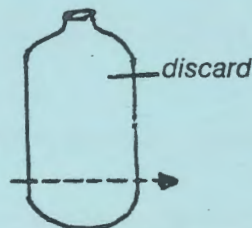
NB: *As this is for revision, only the basic structure and function of each organelle (as done in Std 7) should be dealt with. The detail required in Std 8 will be covered in later lessons.*

1. Cut the three coke bottles (along dotted lines) as shown below.

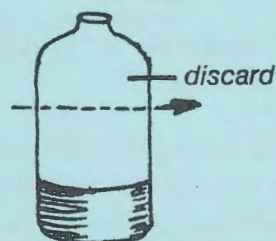
For body of cell



For top of cell



For mixing the gelatine



2. Explain that the rigid supporting cell wall will be represented by the coke bottle. Show that it is strong but flexible. Explain that in most plant cells the wall would not be as thin as this. If a thick glass bottle was used, the thickness of the wall would be shown more accurately.
3. Now line the first cut-off bottle with the large plastic bag. Smooth out the creases as much as possible. Compare this to the cell membrane, and discuss its thinness, structure and function.
4. Mix the gelatine only when you need it, because it will set within 10-15 minutes. Use the plastic teaspoon to mix it in the third cut-off coke bottle. Use 200ml warm water (not boiling) to dissolve 12 teaspoons of gelatine, and then top up with 300ml cold water so that it will set sooner. Discard the bottle and spoon after use.

Explain that this will represent the cytoplasm (colourless and viscous). As you pour it in (only half fill the plastic bag) show how the pressure of the cell contents pushes the cell membrane against the cell wall. Discuss the fact that animal cells do not have the counter-pressure of a containing cell wall. Briefly revise the structure, nature and function of the cytoplasm.

5. Discuss the size and structure of the plant cell vacuole, and ask the pupils how they would represent it in the model. Remind them that it is fluid-filled but that the contents are not as viscous as the cytoplasm. Fill the sandwich bag with water, tie a knot (explain that real cells do not have knots, but that this is just a representative model). Revise the structure and function of the vacuoles in plant and animal cells. Try to elicit the facts from the pupils. Let them tell you, rather than you telling them. This is revision, after all.

NB: A drop of food colouring in the water will make the vacuole more easily visible. If only water is used, the vacuole is impossible to see. (Explain that the vacuole is not really coloured in cells).

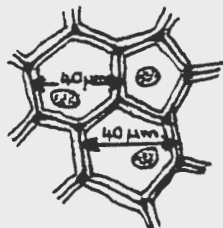
NB: An alternative is to use a small light-coloured balloon filled with water to represent the vacuole.

6. *Using the ping-pong ball (which has had several holes pierced in it with a hot knitting needle) as a model, discuss the basic structure and function of the nucleus. Add it to the model. Show how it is displaced to the side of the cell by the vacuole.*
 7. *Now add the jelly-beans as mitochondria. They are more-or-less the correct size and shape (perhaps a little small), but not the correct colour. Spread them through the "cytoplasm". Revise the basic structure (external only) and function of mitochondria.*
 8. *Add the plasticine "chloroplasts". Point out their size relative to the size of the cell, and relative to the mitochondria. Briefly revise the structure and function of plastids as done in Std 7.*
 9. *Add the remaining "cellular inclusions" (e.g. lysosomes, represented by the pea-sized sweets or blobs of plasticine). Name them and revise their functions.*
 10. *Complete the cell by tying a knot in the plastic bag and adding the last cut-off coke bottle to "close the lid".*
 11. *Get the pupils to discuss in what ways the model is similar to a plant cell and in what ways it is an inaccurate representation.*
 12. *End the lesson with a revision of the differences between plant and animal cells. Start with the obvious differences like the cell wall. Then remove the plant "cell wall" from the model by taking off the "lid" and lifting out the plastic bag. Obviously it is not wise to do this before the gelatine has set, but it should have set by now.*
 13. *Ask if the model now represents an animal cell. How would it differ? Discuss differences such as the lack of plastids in animal cells; the size of the vacuoles in plant and animal cells; the centriole in animal cells.*
- NB: In animal cells the nucleus tends to be much larger relative to the size of the cell than the ping-pong ball in this model.*
14. *Allow the pupils to draw up a tabular summary of the differences on the chalkboard, as the discussion proceeds.*

Thinking about size (AGAIN!)

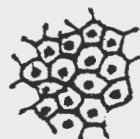
REVISION QUESTIONS:

1. How many of the cells shown here would fit side-by-side across a pinhead with a diameter of 1mm? (Show the steps in your calculation).



Imagine that you have to draw the pinhead to scale. Would you be able to fit it on this page? (Show your calculations for working out your answer.)

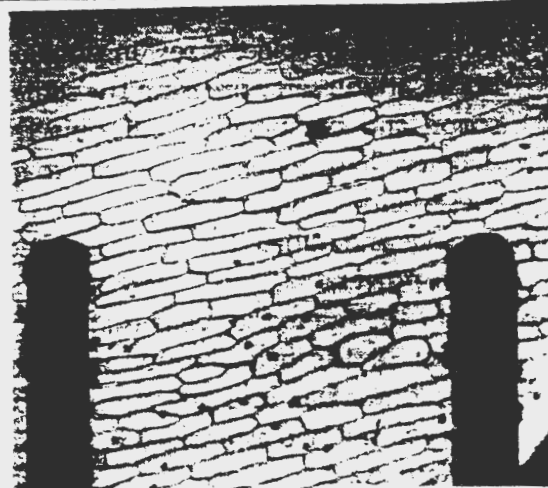
2. If the same cells were drawn 10 times smaller, using a scale of $1\text{mm}=10\ \mu\text{m}$ (as shown here), the pinhead would fit on the page. Using the information provided, calculate the size of the pinhead if drawn to this scale. Show all calculations.



Draw a dotted circle around the cells to represent the pinhead drawn to scale. (Your line may have to overlap some of the writing on this page).

3. This picture shows a piece of onion skin placed on a plastic ruler and viewed under an ordinary light microscope. The two black lines are two of the "millimetre" markings on the ruler. You can see that not all of the cells are exactly the same size.

Work out the average length of these onion epidermis cells. Show your calculations.

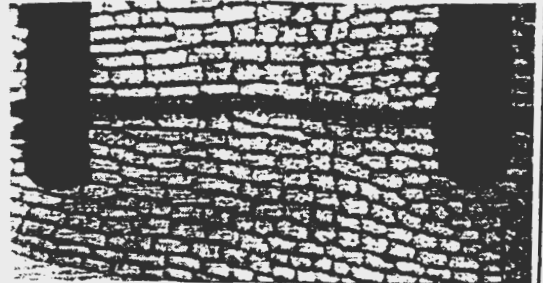


From: Living Biology - 8 (Kaske et al)

NB: Next time you eat an onion, try and pull off a piece of the thin membrane found on around each layer of the onion. This is the onion epidermis. Try and imagine the cells which form it. If five could fit side by side across a pinhead, they are not really all that small!

4. Now try the exercise again, using this photograph of some moss leaf cells. Are they bigger or smaller than the onion epidermal cells?

Calculate the average size of these cells. Show your calculations.



From: Living Biology - 8 (Kaske et al)

You should now be a lot more familiar with the sizes of cells (after this exercise plus last week's lesson on size). It is obvious that cells vary tremendously in size!

But what about the size of the organelles? In the same way that cells can vary in size, so can the organelles in them. These exercises should help you to get an idea of the sizes of organelles relative to the cells in which they occur.

1. The following table lists some plant cell organelles, together with some typical sizes, and the approximate number of each type of organelle found in a typical plant cell. The last column gives sizes of the cell which you are required to draw to scale.

Cell or organelle	no. per cell	typical size	size for drawing and no. to draw
cell (length)	-	-	35 μ m
thickness of wall	-	-	0.5 μ m
nucleus (diameter)	1	10-20 μ m	15 μ m (X 1)
chloroplast (length)	50-200	5-10 μ m	8 μ m (X 3)
mitochondrion (length)	500-2500	2-5 μ m	3 μ m (X 10)
golgi body (diameter)	1	-	4 μ m (X 1)

Using the measurements given in the last column, draw yourself a typical plant cell. Make it five-sided. Put in the number of organelles of each type shown in brackets in the last column of the table. Use a scale of 1mm = 1 μ m.

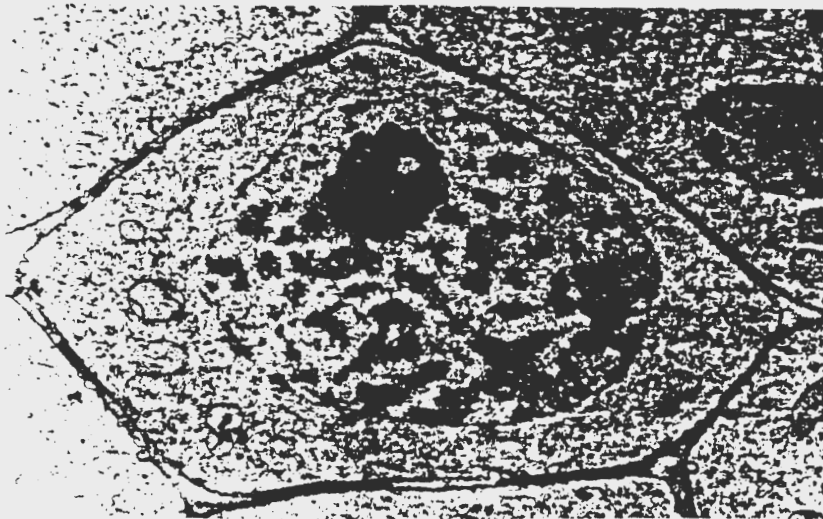
2. To show you how size can vary, answer the following questions, using this photograph of a cell from a clover plant.

- a. What is the actual length of the chloroplast in μm ?
- b. What is the actual diameter of the nucleus in μm ?
- c. What is the length of the longest mitochondrion (in μm)?
- d. How thick is the cell wall in μm ? NB: measure the wall of one cell, not the walls of two adjoining cells.
- e. What is the length of the largest vacuole?

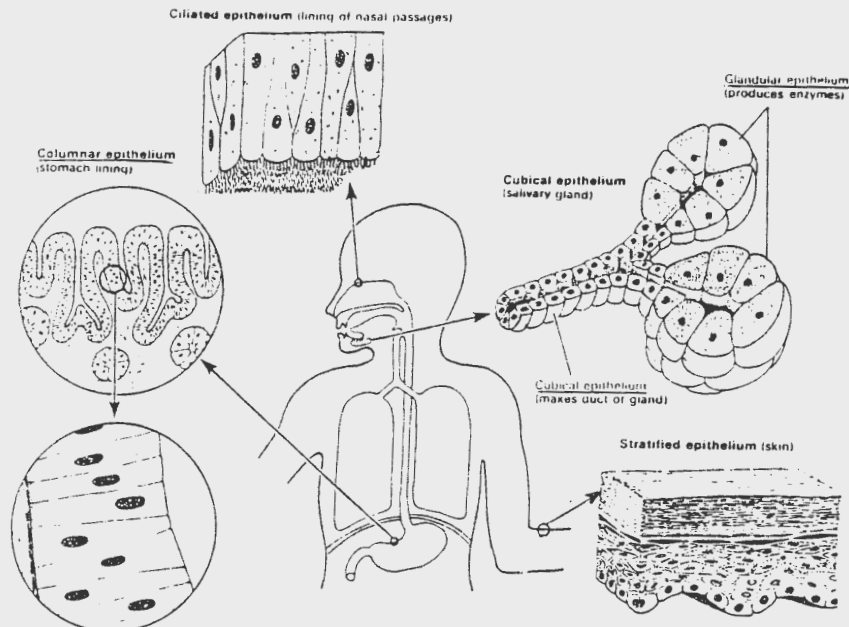


From: The cell (SACHED, 1981)

Now look at this plant cell, from the growing shoot of wheat. Look at the size of the nucleus relative to the cell.



3. This diagram shows some of the types of epithelial tissues found in the human body. Remember that a tissue is made up of a group of cells with a similar structure and function.



Let us look at one columnar epithelial cell from the stomach lining, one cuboidal epithelial cell from the duct of the salivary gland, and one glandular epithelial cell from the salivary gland itself. To simplify matters, the largest cell of each type (in the drawing) has been copied into the blocks below.

For each cell type, work out approximately how many nuclei from that cell could fit across the diameter of the cell. Fill in the answers on the dotted lines below the drawings.

columnar
epithelial cell



cuboidal
epithelial cell



glandular
epithelial cell

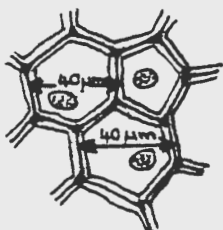


So you can see that the size of the nucleus relative to the size of the cell can differ quite substantially!

Thinking about size (AGAIN!)

Measurements given in this answer sheet reflect sizes on the original worksheets. All teaching materials included in this Volume have been reduced to 85% of original size to fit them onto the pages.

1. How many of the cells shown here would fit side-by-side across a pinhead with a diameter of 1mm? (Show the steps in your calculation).



Diameter of pinhead = 1mm
= 1000μm

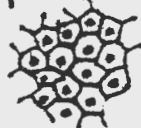
If cell is 40μm across
You would fit $\frac{1000}{40} = 25$ across the pinhead

Imagine that you have to draw the pinhead to scale. Would you be able to fit it on this page? (Show your calculations for working out your answer.)

Measure the cells: 40μm is 1.5cm on this page
∴ 10μm is 0.4cm
∴ 1000μm is 40cm

The pinhead would have to be 40cm across.
The page is only 21cm wide - too small to draw the pinhead to scale.

2. If the same cells were drawn 10 times smaller, using a scale of 1mm=10μm (as shown here), the pinhead would fit on the page. Using the information provided, calculate the size of the pinhead if drawn to this scale. Show all calculations.



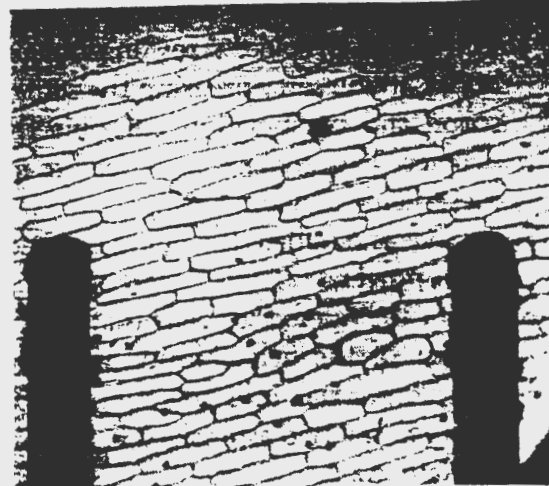
1mm = 10μm
∴ 1000μm (size of pin) = 100mm.

approximate size of pinhead. ←

Draw a dotted circle around the cells to represent the pinhead drawn to scale. (Your line may have to overlap some of the writing on this page).

3. This picture shows a piece of onion skin placed on a plastic ruler and viewed under an ordinary light microscope. The two black lines are two of the "millimetre" markings on the ruler. You can see that not all of the cells are exactly the same size.

Work out the average length of these onion epidermis cells. Show your calculations.



About 4 cells fit (lengthwise) between the 1mm markings
∴ 1 cell = $\frac{1\text{mm (or } 1000\mu\text{m)}}{4}$

∴ Average length of onion cell = 250μm

From: Living Biology - 8 (Kaske et al)

NB: Next time you eat an onion, try and pull off a piece of the thin membrane found on around each layer of the onion. This is the onion epidermis. Try and imagine the cells which form it. If five could fit side by side across a pinhead, they are not really all that small!

4. Now try the exercise again, using this photograph of some moss leaf cells. Are they bigger or smaller than the onion epidermal cells?

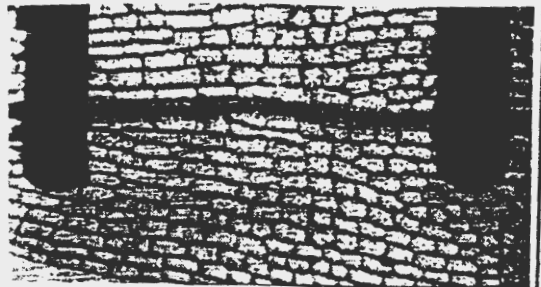
Smaller

Calculate the average size of these cells. Show your calculations.

About 12 fit into 1mm (1000µm)

∴ average length of 1 cell

= ± 83µm



From: Living Biology - 8 (Kaske et al)

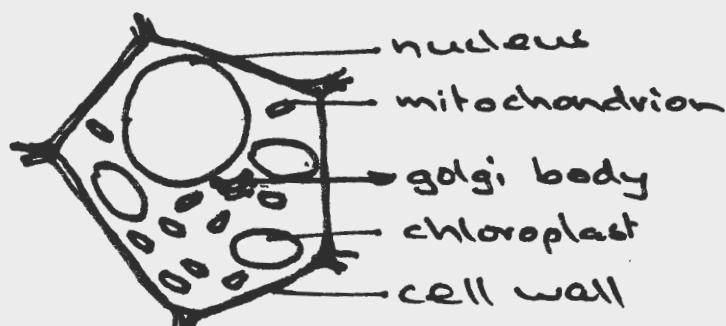
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1. The following table lists some plant cell organelles, together with some typical sizes, and the approximate number of each type of organelle found in a typical plant cell. The last column gives sizes of the cell which you are required to draw to scale.

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chloroplast (length)	50-200	5-10µm	8µm (X 3)
mitochondrion (length)	500-2500	2-5µm	3µm (X 10)
golgi body (diameter)	1	-	4µm (X 1)

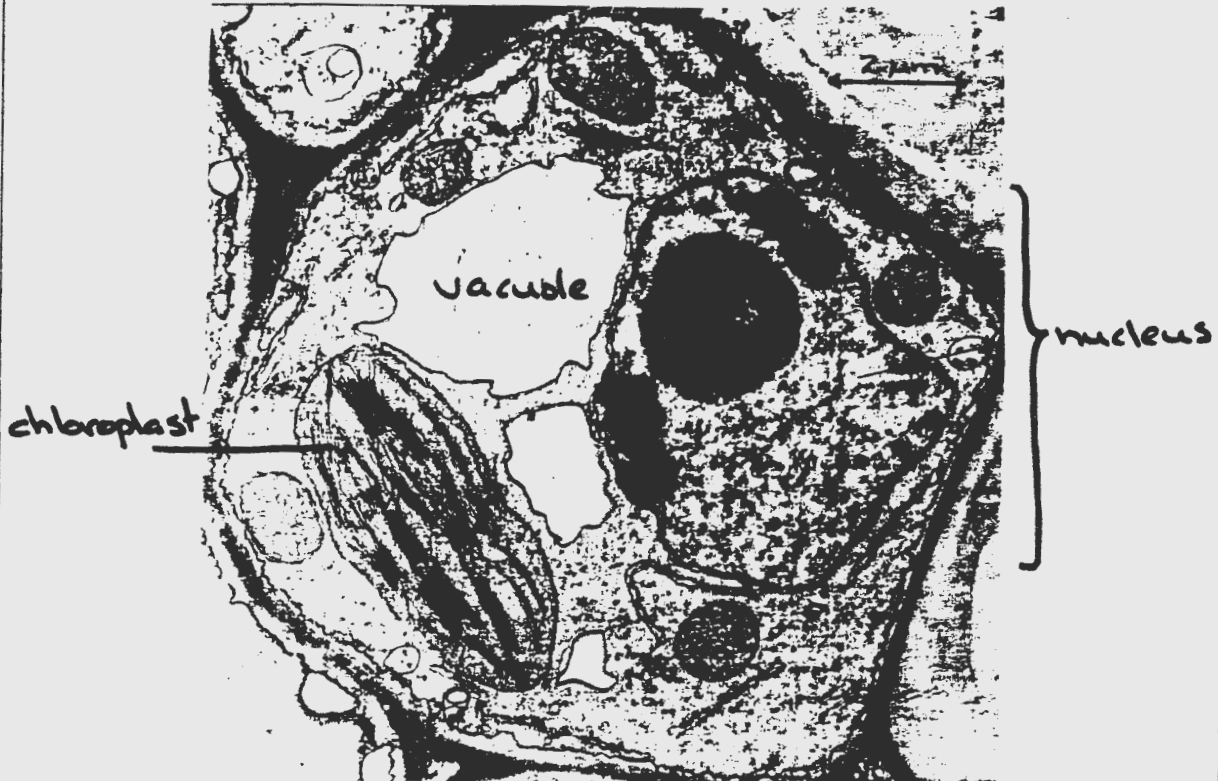
Using the measurements given in the last column, draw yourself a typical plant cell. Make it five-sided. Put in the number of organelles of each type shown in brackets in the last column of the table. Use a scale of 1mm = 1µm.



2. To show you how size can vary, answer the following questions, using this photograph of a cell from a clover plant.

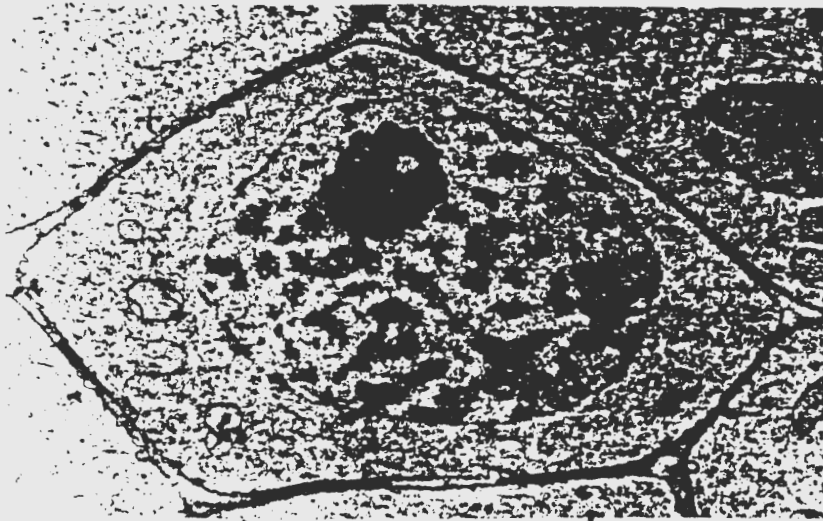
$2\mu\text{m} = 2\text{mm}$ (on this page) $1\text{cm} = 1\mu\text{m}$

- a. What is the actual length of the chloroplast in μm ? $6\text{cm} = 6\mu\text{m}$
 b. What is the actual diameter of the nucleus in μm ? $\pm 5-6\text{cm} = \pm 5-6\mu\text{m}$
 c. What is the length of the longest mitochondrion (in μm)? $2\text{cm} = 2\mu\text{m}$
 d. How thick is the cell wall in μm ? NB: measure the wall of one cell, not the walls of two adjoining cells. $2\text{mm} = 0,2\mu\text{m}$
 e. What is the length of the largest vacuole? $\pm 4,5\text{mm} = \pm 4.5\mu\text{m}$



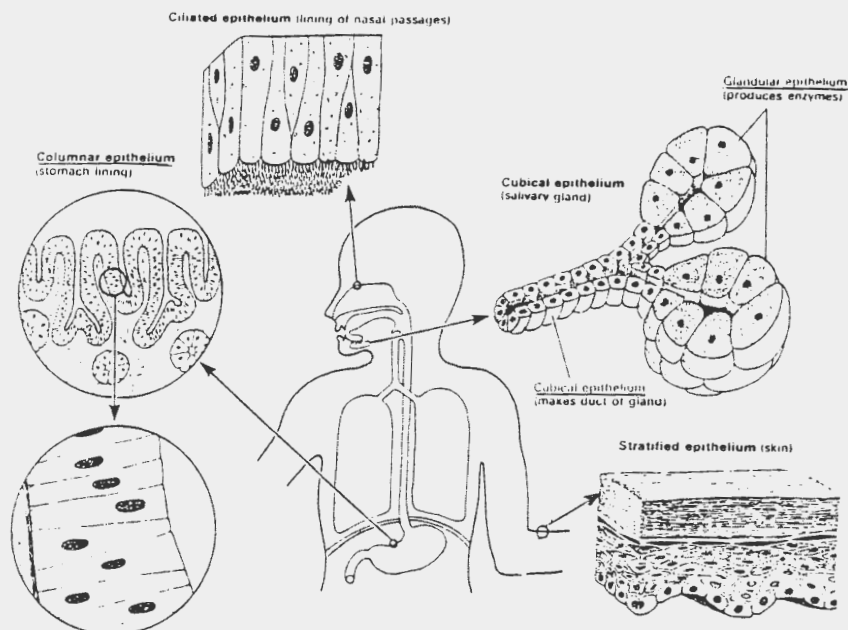
From: The cell (SACHED, 1981)

Now look at this plant cell, from the growing shoot of wheat. Look at the size of the nucleus relative to the cell.



nucleus almost fills cell

3. This diagram shows some of the types of epithelial tissues found in the human body. Remember that a tissue is made up of a group of cells with a similar structure and function.



Let us look at one columnar epithelial cell from the stomach lining, one cuboidal epithelial cell from the duct of the salivary gland, and one glandular epithelial cell from the salivary gland itself. To simplify matters, the largest cell of each type (in the drawing) has been copied into the blocks below, enlarged proportionally.

For each cell type, work out approximately how many nuclei from that cell could fit across the diameter of the cell. Fill in the answers on the dotted lines below the drawings.

columnar
epithelial cell

cuboidal
epithelial cell

glandular
epithelial cell



cell = 8mm diameter
nucleus = 4mm wide
 $\therefore 8/4 = 2$ would fit



cell = 4mm diam.
nucleus = 3mm wide
 $4/3 = \text{only } 1\frac{1}{3} \text{ would fit}$



cell = ± 1 cm diam
nucleus = 2mm wide
 $10/2 = 5$ would fit

So you can see that the size of the nucleus relative to the size of the cell can differ quite substantially!

Teacher's comments on lesson

School: _____ Teacher: _____ Lesson No. _____

Time spent on lesson: _____

How lesson was taught: Please mention briefly how the lesson was dealt with e.g. teacher demonstration, whole class exercise, small group work, individual pupil work etc.

When exercises were done: Please mention (for each exercise) if these were done in class, or for homework.

Checking of answers: Please indicate whether the pupils' answers were checked, and if so, how this was done (e.g. answers displayed on a board, and pupils given 5 minutes at start of lesson to check their homework, or teacher went over answers in class at the end of the lesson etc.)

COMMENTS

Problems experienced by teacher:

Problems experienced by the pupils:

General comments on the lesson:

LESSON 6 and OTHERS

(Cells and organelles are 3-D)

Purpose of lessons

1. To emphasise the relative sizes of cells and organelles.
2. To emphasise cells and organelles as 3-D structures.
3. To provide teaching and learning activities which make the pupils think about SECTIONS of cells and organelles, and how they would look if viewed from different perspectives.

Requirements for lessons

1. Overhead transparencies
 - it depends on how you look at it
 - cell membrane
 - nucleus
 - endoplasmic reticulum
 - mitochondrion
 - golgi body
 - chloroplast
2. Worksheets (1 per pupil)
 - cell walls and cell membranes
 - the nucleus is 3-D
 - the endoplasmic reticulum is 3-D
 - vacuoles are 3-D
 - mitochondria are 3-D
 - the golgi body is 3-D
 - chloroplasts are 3-D
3. Micrographs and stereograms
 - set on cell walls and membranes
 - set on nuclei
 - set on the endoplasmic reticulum
 - set on vacuoles
 - set on mitochondria
 - set on golgi bodies
 - set on chloroplasts

4. Plasticine or play-dough for pupils' models of organelles. (The recipe for playdough is given in the worksheet "Can you interpret stereograms?").

Points to make to the pupils

1. Biologists' current understanding of the structure of the cell is the result of years of "detective work", obtaining clues from 2-D microscope sections and using them to build theories of what the structures would look like in 3-D.

Use the OHT "it depends on how you look at it" to show that (for example) a circular shape seen when looking down a microscope could have been obtained from a whole range of DIFFERENT 3-D shapes.

2. Give the pupils the **Brain-teaser No. 2** exercise, which simulates the sort of activities a biologist could go through trying to discover more about the structure of a cell.

Give them a couple of days to work on a solution. Set aside a noticeboard where they can display their sketches on the due date. Allow the class to examine the results and to vote on which is the most likely theory, based on the evidence available.

3. Tell the pupils that the purpose of the next series of lessons is to ensure that they develop a 3-D understanding of the structure of cells and organelles.

This will be done by using stereograms, electron micrographs, worksheets which are designed to get them thinking about the 3-D nature of cells, and by pupils building small plasticine models of each organelle they study.

4. Point out that the photos on the worksheets are not always of a good quality, but are there so that each child has a copy of them. Pupils will be using larger, better quality micrographs as they work in small groups to complete the exercises.
5. Keep reminding the pupils that the sorts of exercises in the worksheets are similar to those which faced the biologists who tried to interpret the first electron micrographs of cells in order to work out the structure of the organelles they were investigating.

To the teacher

1. You should proceed with these lessons as you see fit. However, to consolidate the work done on each organelle, it is suggested that the pupils work in small groups, each with a set of "good" electron micrographs. Allow them to discuss the various answers as they complete the worksheets. Verbalising their ideas is an important part of the learning process. Some of the questions can be completed at home, as they are

not based on the micrographs. The answers should be discussed with the pupils, either at the end of the lesson or at the start of the following lesson. It is important that you go over the exercises with the pupils, once they have completed them.

2. Please ask the pupils not to mix the colours of plasticine. Recover the plasticine after each exercise, and use it for the next lesson.

Really encourage the pupils to model each organelle as they learn about it. Such activities help pupils to understand the 3-D structure of the organelles. Even the simple task of modelling the external shapes of nucleus, mitochondrion, chloroplast, golgi body, ER etc. will be useful. Further models of internal structures (e.g. of mitochondria and chloroplasts) will be of even greater value, as pupils often struggle to understand these structures.

Put aside a shelf on which they can display the models they make. Encourage them to examine and discuss the models at the start or finish of lessons.

Drawing exercises

Teachers are asked to constantly remind the pupils of the importance of accurate observation and drawing. The drawing exercises should not involve merely copying from the textbook, but getting the pupils to draw from micrographs (either photographs, 35mm slides, or overhead transparencies.)

Micrographs and diagrams used for the pupil activities were obtained from the following sources, which are gratefully acknowledged.

- ASEP. (1974). *Cells, the unit of life. Teacher edition*. Melbourne: Australian Science Education Project.
- DE DUVE, C. (1984). *A guided tour of the living cell*. New York: Scientific American Books.
- DILLEY, L. (1986). *The cell: A workbook for biology students*. Braamfontein (South Africa): SACHED Trust / Raven Press
- HEAD, J. (1975). *Student's collection of electron micrographs*. London: Edward Arnold.
- HURRY, S. (1965). *The microstructure of cells*. London: John Murray.
- JENSEN, W. and PARK, R. (1968). *Cell ultrastructure*. Belmont (California): Wadsworth Publishing Company.
- LEDBETTER, M. and PORTER, K. (1970). *Introduction to the fine structure of plant cells*. Berlin: Springer-Verlag.
- PFEIFFER, J. (1969). *The cell*. Nederland (NV): Time-Life International.
- STARR, C. and TAGGART, R. (1987). *Biology: The unity and diversity of life* (Fourth Ed.). Belmont (California): Wadsworth Publishing Company.

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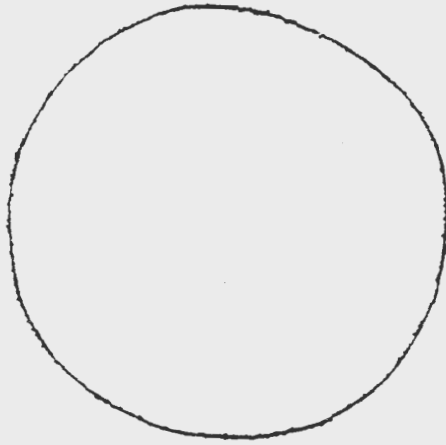
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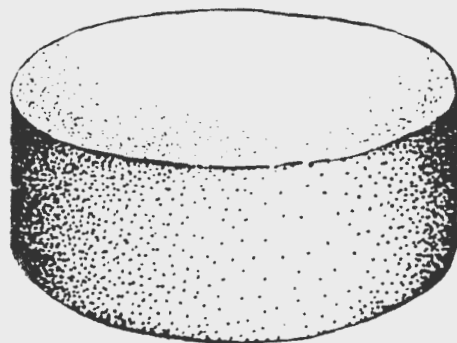
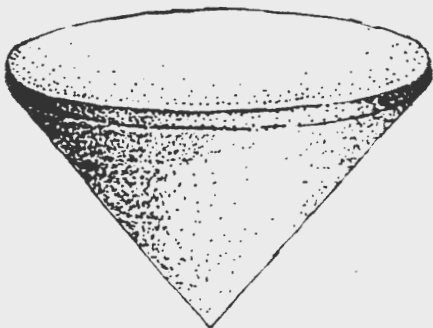
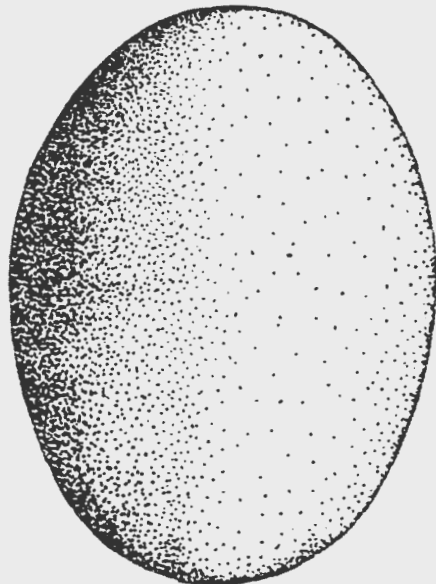
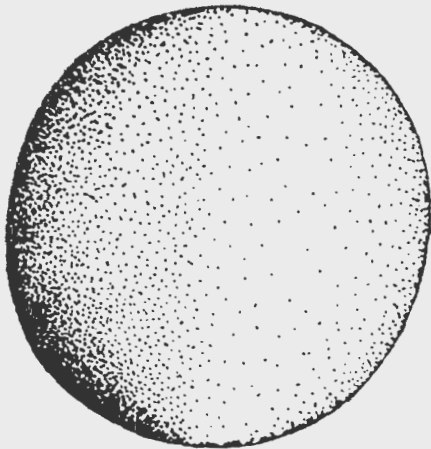
IT DEPENDS HOW YOU LOOK AT IT

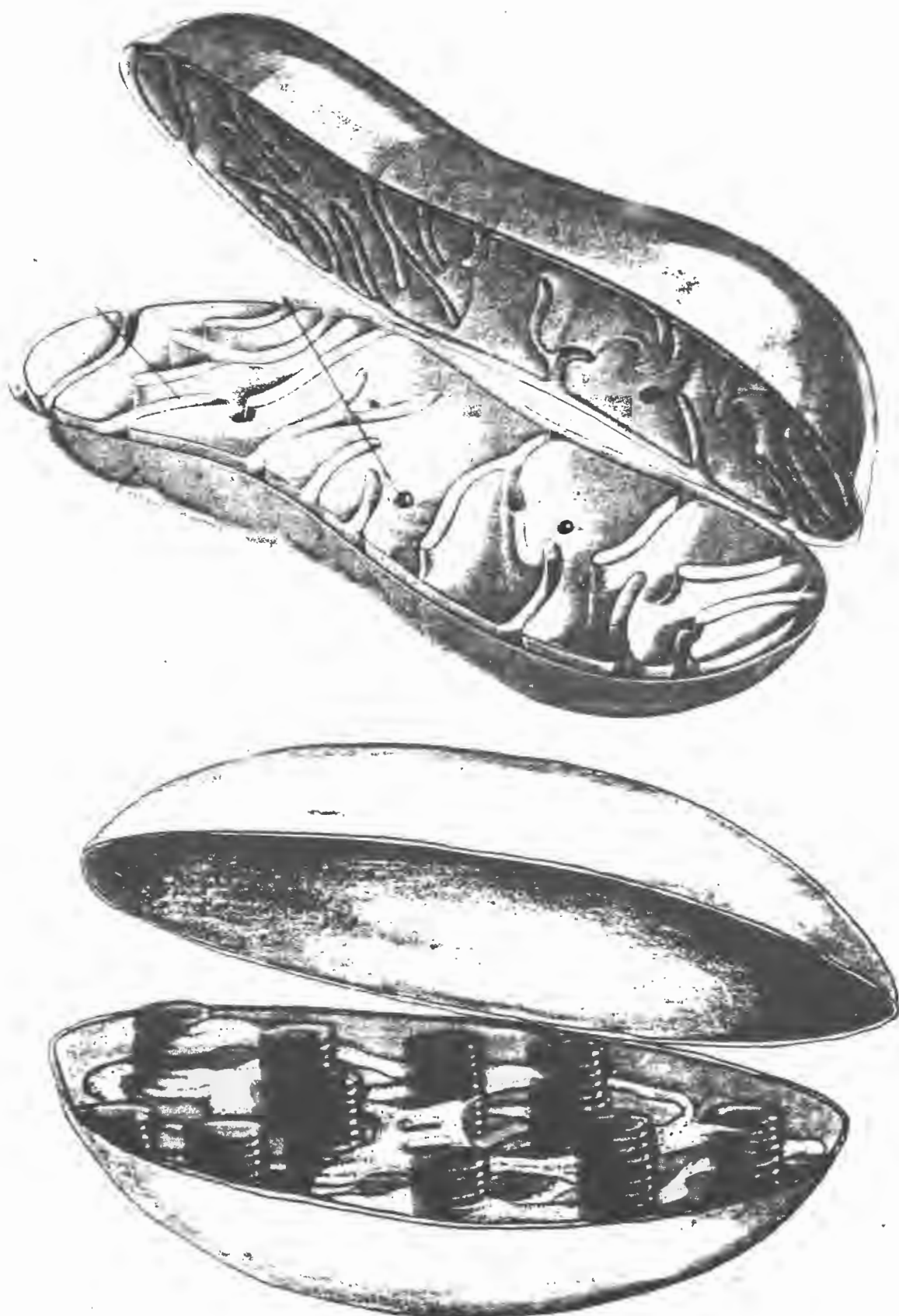
When looking at cells, remember that what you see depends on the direction from which you look at it.

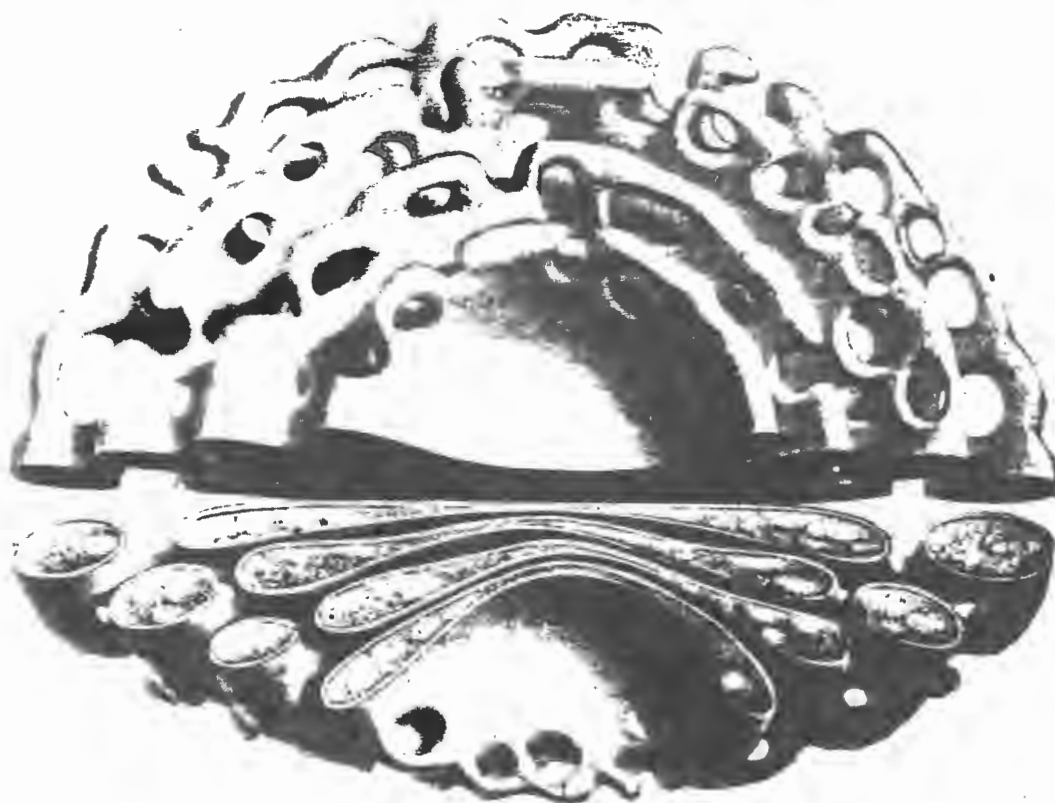
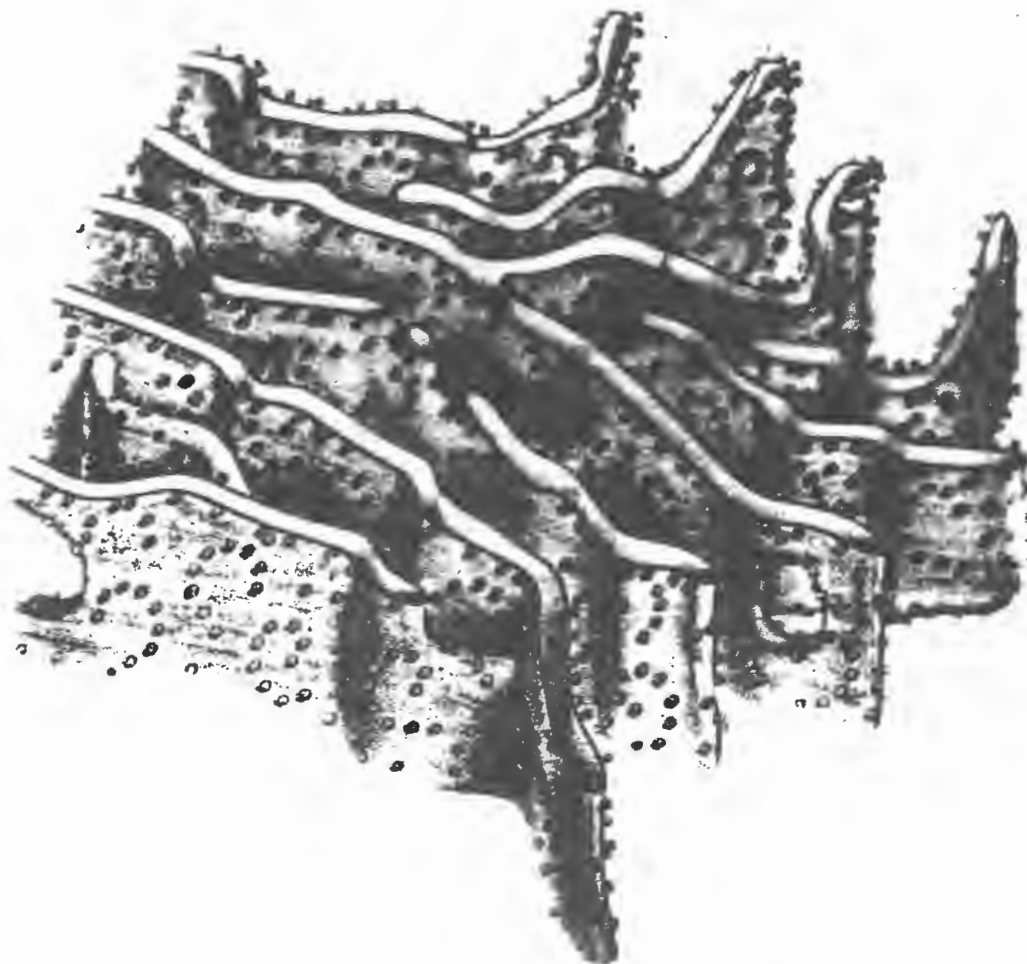
For example, something viewed through a microscope may look like this.

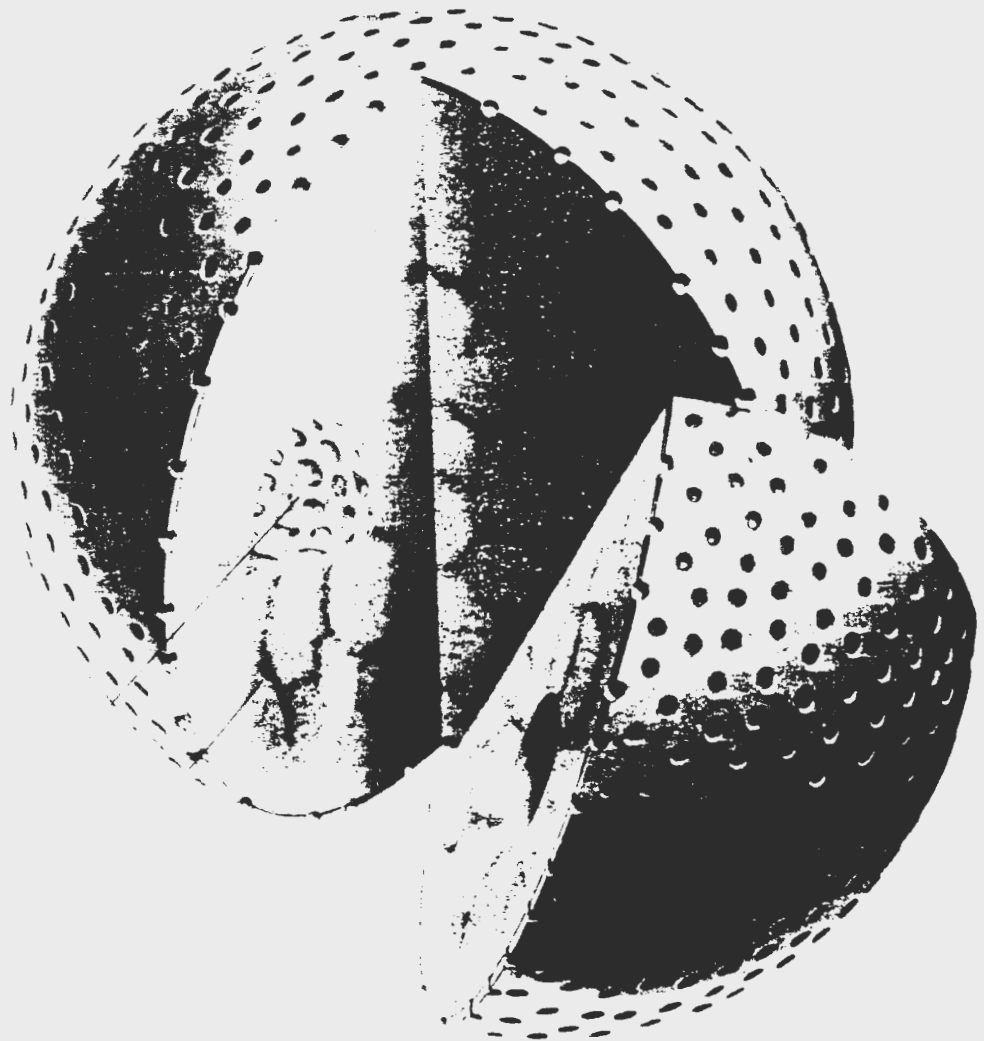
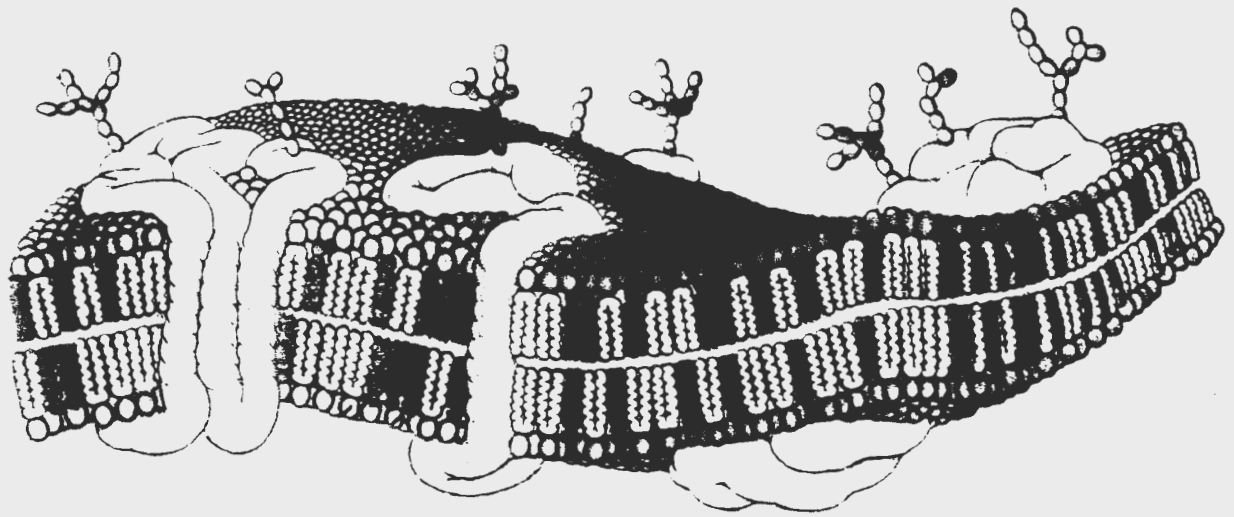


But the same thing could actually be shaped like any of these.



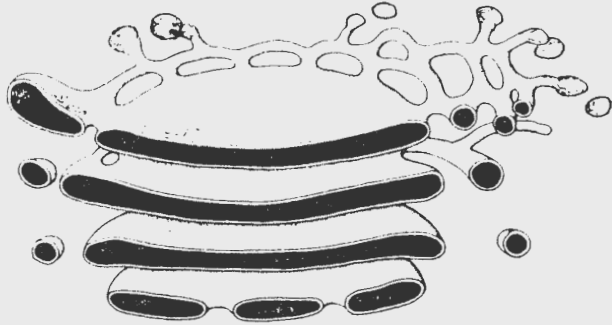






THE GOLGI APPARATUS IS 3-D

- 1.1 Carefully examine this stereogram of a golgi body. Label the following structures:- cisternae, vesicle, dictyosome

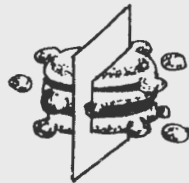


2. Would the appearance of a golgi body be the same or different if it were sectioned in the two different planes shown below? _____

length-wise in the plane of the page



length-wise at right-angles to the plane of the page



3. What would it look like if it were cut in cross-section? Draw YOUR impression of its appearance.

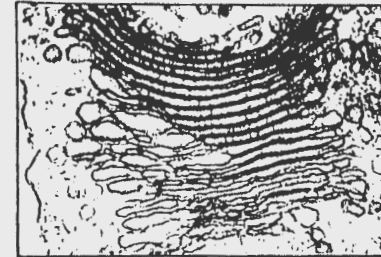
- 4.1 Use the scale provided to estimate the width and height of the golgi body in the cell on the upper left in the following electron-micrograph.

width _____ μm height _____ μm

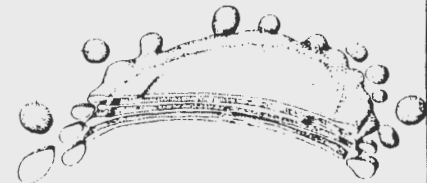
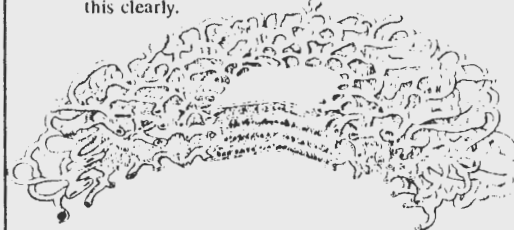


- 4.2 Approximately how many vesicles can you see in this golgi body? _____

- 4.3 How many vesicles are there in the following golgi apparatus? _____



You can see that the structure of golgi bodies can vary widely. The following two diagrams illustrate this clearly.



5. Briefly state the function(s) of the golgi body.

CELL WALLS AND CELL MEMBRANES

- 1.1 In this electron micrograph of some cells from the root tip of a bean, the cell wall of the lower cell is particularly clear. Use the scale provided to estimate the average thickness of the cell wall in μm . Show your calculations.



- 1.2 The plasmalemma (cell membrane) is also clearly visible. Label the cell wall and the plasmalemma on your diagram.

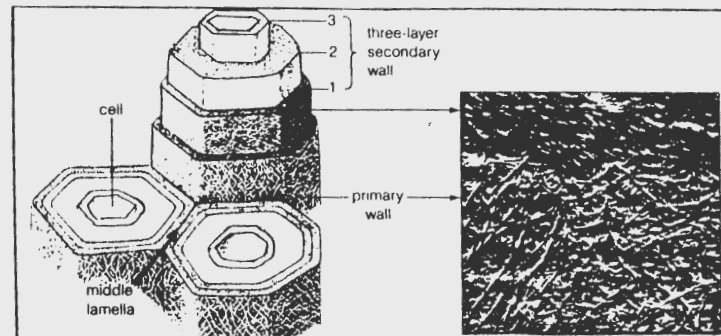
- 2.1 Carefully examine the electron micrograph shown below, and decide if it shows plant or animal cells. List THREE reasons (visible in the micrograph) for your answer.

1. _____
2. _____
3. _____



- 2.2 Use the scale provided to estimate the thickness of the cell wall (in μm). Show how you got your answer. _____ μm

- 3.1 Examine the following diagram of plant cell walls. Label the **plasmalemma** and the **cytoplasm** of one of the cells.



- 3.2 Which layer is ALWAYS present, and forms the dividing barrier between two adjacent plant cell walls? _____

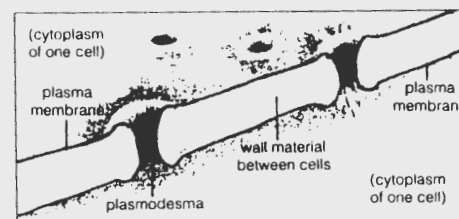
- 3.3 As the cell wall thickens, which layer is deposited next? _____

- 3.4 Write down the names of the four layers of the cell wall shown, in the order in which they were added to the cell. _____

- 3.5 When a cell wall thickens, is the new layer added on the INSIDE of the cell (next to the cell membrane) or on the OUTSIDE (next to the middle lamella)? _____

- 3.6 Examine the electron micrograph to the right of the diagram. The cellulose fibres which make up the wall can be clearly seen. Label a cellulose fibre on the photograph.

- 4.1 This diagram shows the structure of some of the plasmodesmata between two cells. Make sure that you understand what the picture shows, as it is drawn from an unusual angle. If you are not sure, discuss it with your friends.



The cell wall between the two cells is the white band from the bottom left to the top right of the picture, and it has been sectioned (cut) to show two plasmodesmata linking the adjacent cells.

In the top left of the diagram the openings of two plasmodesmata can be seen, viewed from above looking down on the surface of the cell wall.

Note that the cell membranes of the two cells actually join inside the plasmodesmata.

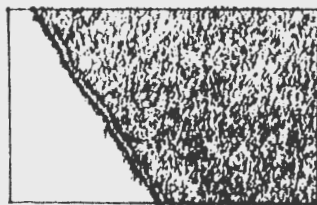
Explain in your own words WHAT a plasmodesma (plural = plasmodesmata) is, and what function it serves.

4.2 The electron micrograph on the left shows a surface view of a cell wall, with the openings of the plasmodesmata clearly visible as holes in the cell wall. Label one plasmodesma on your photograph.



The electron micrograph on the right shows a highly magnified portion of a cell wall, very similar to the picture in 4.1. Identify and label the cell wall, the plasmalemma (cell membrane), and the TWO plasmodesmata visible in YOUR photograph.

5. These electron micrographs are extremely highly magnified, far beyond any of the electron micrograph pictures you would normally see. They show a single cell membrane (called the unit membrane).



Part of a human red blood cell.

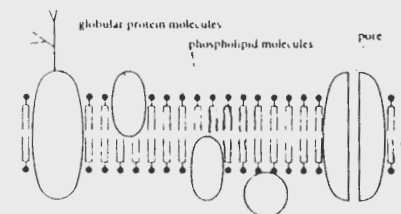
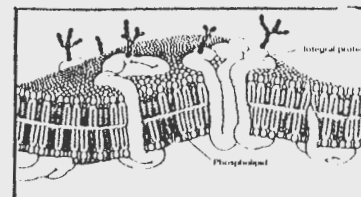


Part of a toad egg.

They show that the single membrane appears to be made up of three layers - a light inner layer sandwiched between two dark outer layers.

When biologists first saw this, they conducted experiments to find out more about the layers. They worked out that the cell membrane contained phospholipids and proteins, and they decided that the outer (darker) zones were layers of protein, and the inner (light) zone was made up of TWO layers of phospholipid molecules.

The following diagram shows a more recent interpretation of the structure of the membrane.



Locate the double (inner) layer of phospholipid molecules. Now locate the proteins. Notice that they do not form a solid layer on each side of the phospholipid layer, but rather they are embedded in it. They are able to shift around in the lipid layer, rather like life-buoys floating in a sea of treacly phospholipids.

Examine the new model and then explain what structures YOU think make up the dark outer layers and the light inner layer seen by early electron microscopists.

6. Carefully examine the following electron micrograph. How many cell membranes can you see?



Would you say that this is the outer membrane of a single animal cell, or the cell membranes of two adjoining cells? _____

Justify (explain) your answer.

7. Briefly state the functions of

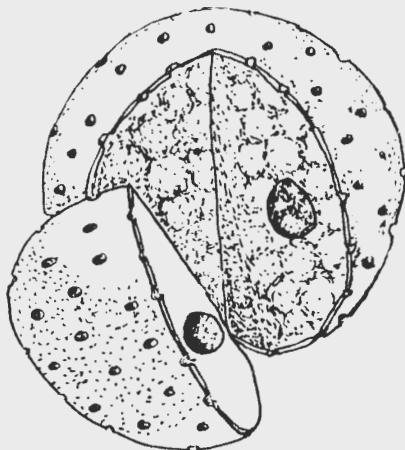
a) Cell walls

b) Plasmodesmata

c) The cell membrane (plasmalemma)

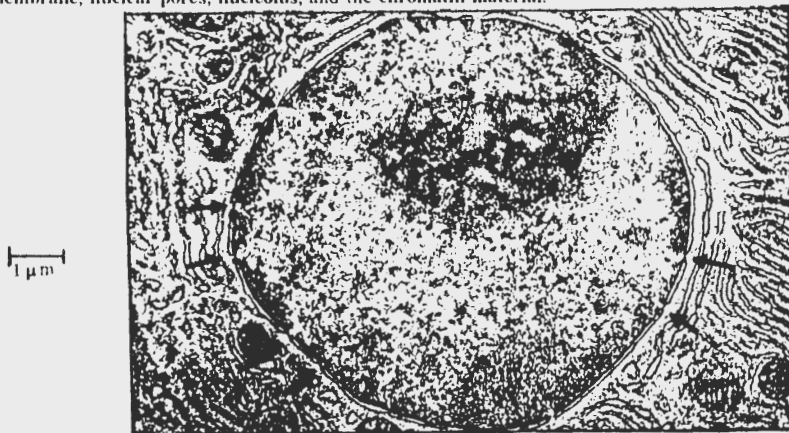
THE NUCLEUS IS 3-D

- 1.1 Examine the stereogram (3-D picture) provided below. If you had to describe the 3-D shape of the nucleus, with what common object would you compare it? _____



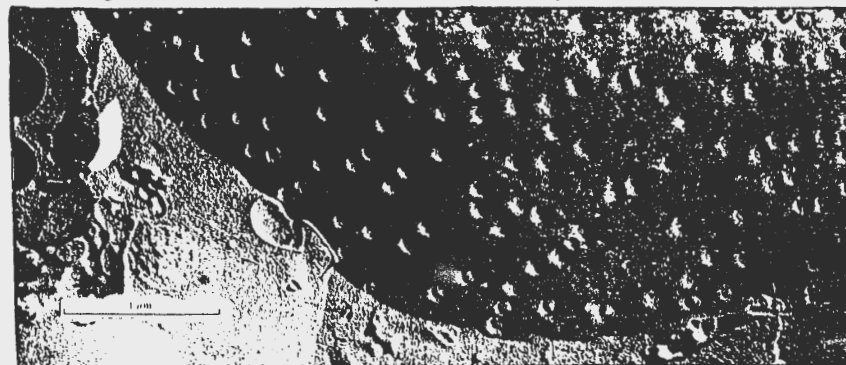
- 1.2 Add the following labels to the diagram above: **nuclear membrane**, **nuclear pore**, **chromatin material**, **nucleolus**.

- 2.1 This electron-micrograph shows a close-up view of a nucleus. Locate and label the double nuclear membrane, nuclear pores, nucleolus, and the chromatin material.



- 2.2 Use the scale provided to work out the diameter of the nucleus (_____ μm) and the length of the rather irregularly shaped nucleolus (_____ μm).
- 2.3 What other structures (clearly visible in the photograph) are often attached to the nuclear membrane?

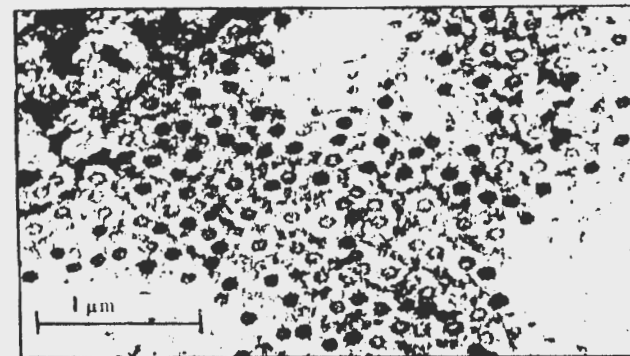
3. This amazing surface view of a nucleus was produced by a technique called freeze-etching.



The living specimen is quickly frozen to a temperature of about -100°C . A razor blade or the blade of a microtome (cutting machine) is then used to split or fracture the specimen along its lines of weakness. A mould is then made of the structure, using carbon. This, in turn, is used to produce a platinum 3-D replica of the original, which can then be viewed using a scanning electron microscope, which allows the viewer to see the specimen in 3-D.

What are the circular holes shown in the micrograph? _____

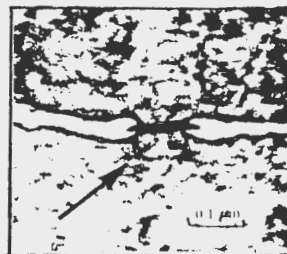
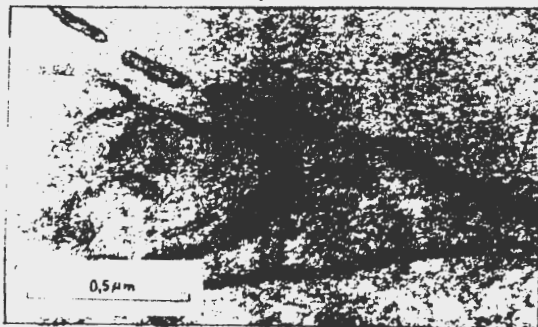
4. This electron micrograph shows the surface view of a nuclear membrane, with the nuclear pores clearly visible.



- 4.1 Use the scale provided to estimate how many pores, if placed side-by-side, would fit into 1 μm.

- 4.2 Now work out the average diameter of the nuclear pores shown. Show your calculations.

5. This close-up of the nuclear envelope clearly shows the double nature of the membrane, and the structure of several nuclear pores.



Biologists have found that in the nuclei of some cells, a membrane is stretched across the pores, probably to control the passage of certain substances into or out of the nucleus.

Carefully examine the two micrographs above. Which one (left or right) shows such membranes across the pores? _____

Diagram of nuclear pores with no selective membrane

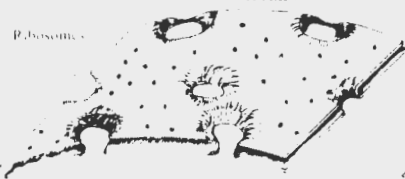
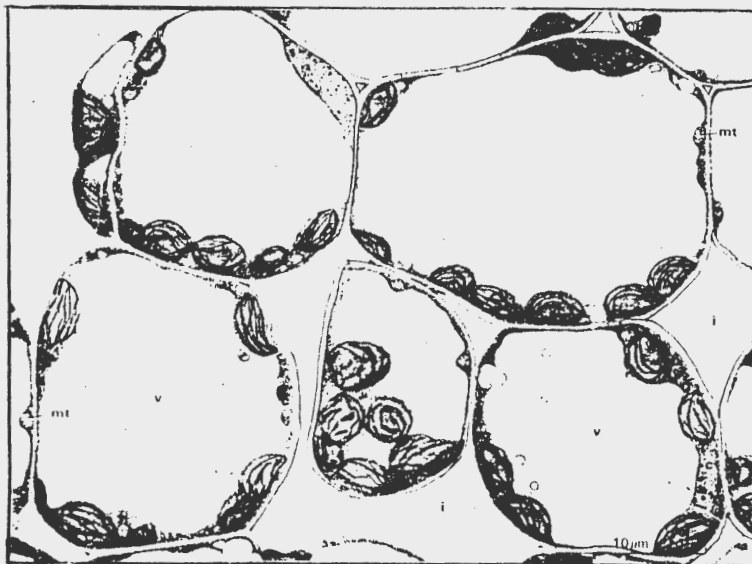


Diagram of nuclear pores with selective membrane



6. Carefully examine this electron micrograph, and then answer the questions which follow.



- 6.1 Are these plant or animal cells? _____
Justify (give reasons for) your answer.

- 6.2 Only one of the cells appears to have a nucleus, which is squashed against the cell wall. Locate and label this nucleus on your photograph.
- 6.3 Can you work out why the other cells do not appear to have nuclei? Explain your theory for this mysterious fact. If you need a hint to help you, look at the bottom of this page.

7. Briefly explain the functions of
- the nucleus

b) the nuclear pores

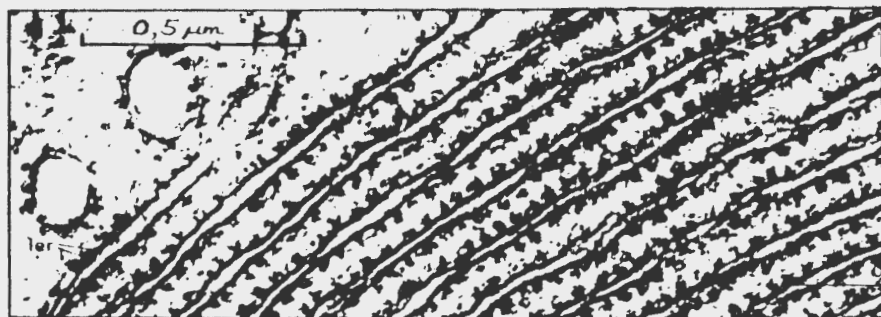
c) the chromatin material

d) the nucleolus

Hint: It has to do with where the section was cut through the cell.

THE ENDOPLASMIC RETICULUM IS 3-D

- 1.1 Carefully examine the rough endoplasmic reticulum shown in the following micrograph. Label the endoplasmic reticulum and the ribosomes which give it the name of "rough" ER.



- 1.2 Are the ribosomes on the inside or the outside of the endoplasmic reticulum?

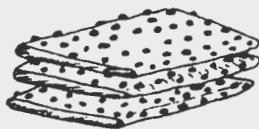
2. Biologists, when first faced with electron-micrographs of the ER (like the one above) had to try to work out what endoplasmic reticulum looked like in 3-D. Look again at the photograph in question 1, and try to decide how YOU would interpret the 3-D structure.

They came up with two possible models, both of which, if sectioned, would appear like the photograph.

Model 1: A series of hollow tubes, coated with ribosomes



Model 2: a series of hollow sheets, coated with ribosomes

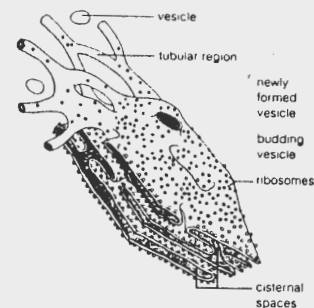


- 2.1 Which of these two models do YOU think is the most likely one? _____

(HINT: Try to imagine what a section through each of the models is likely to look like).

- 2.2 Justify your answer to 2.1.

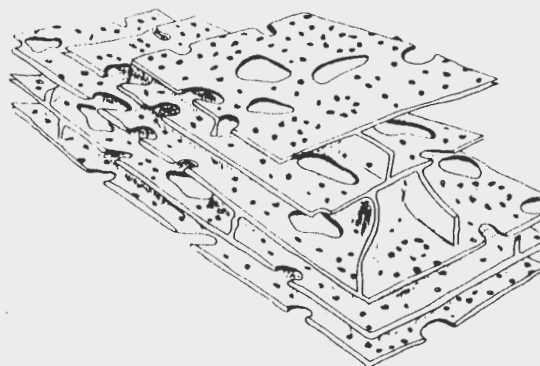
- 2.3 A third model is also possible, one where parts of the ER are in sheets, and parts are tubular as shown below.



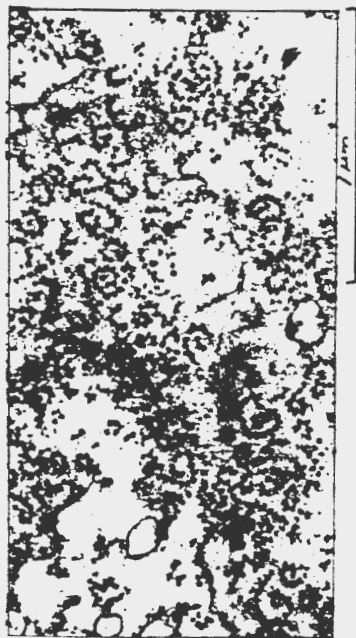
What would you expect a section to look like if it were cut through ER which had a structure as described by this third model?

Look at the electron micrograph in question 1. Do you see any "evidence" to support the third proposed model? _____ Explain.

3. Label this 3-D representation of some rough endoplasmic reticulum.



4. This electron micrograph shows an unusual view of some rough ER. Can you work out from which direction it was viewed to give this appearance?

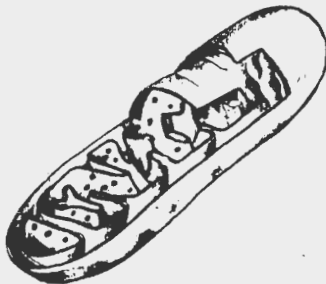


5. Briefly state the functions of
a) smooth endoplasmic reticulum

b) rough endoplasmic reticulum

MITOCHONDRIA ARE 3-D

1. Examine the following stereogram of a mitochondrion.



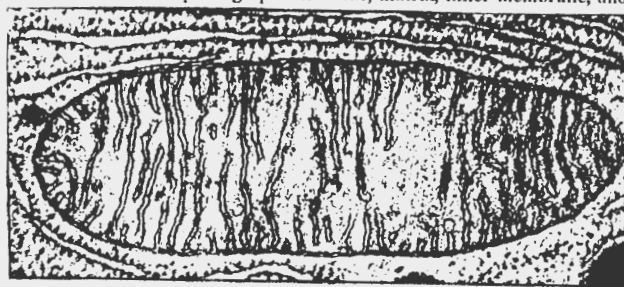
1.1 Label the following structures on your diagram: **cisternae**, **matrix**, **enzyme molecule**, **inner membrane**, and **outer membrane**.

1.2 Would you say that the inner membranes run parallel to the longitudinal axis of the mitochondrion, or at right angles to the axis? _____



NB: This is a major difference between mitochondria and chloroplasts.

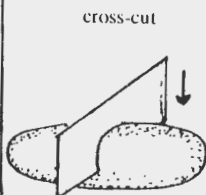
2.1 Carefully examine the following electron micrograph of a mitochondrion, and then label the following structures on YOUR photograph: **cisternae**, **matrix**, **inner membrane**, and **outer membrane**.



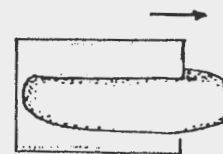
0,5 μm

2.2 Use the scale provided to estimate the length and the width of the mitochondrion.
length _____ μm width _____ μm . Explain how you worked out your answers.

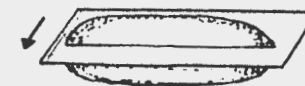
2.3 In which of the following possible planes must the mitochondrion have been cut to produce a section with the inner membranes arranged as they are in the micrograph?



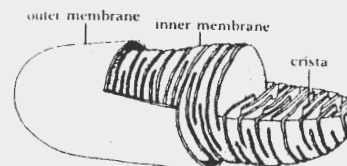
longitudinal cut in the plane of the page



longitudinal cut at right-angles to the plane of the page



2.4 Would the mitochondrion look any different if it were cut longitudinally at right angles to the way it has been cut? _____ Use the diagram shown below to help you to work out your answer.

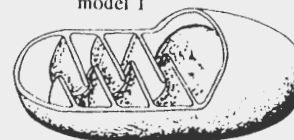


Structure of a mitochondrion

Much of the outer membrane has been cut away, and the interior has been sectioned to show how the inner membrane folds into cristae. The mitochondria of metabolically very active cells have more cristae than those of less active cells.

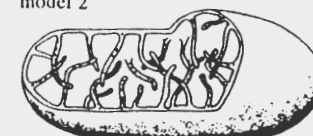
3. Look at the following two diagrams, which represent two different models to explain the 3-D structure of the cisternae of mitochondria.

model 1



Shelf-like projections

model 2



Finger-like projections

3.1 Try to imagine the models in 3-D. Draw what you think a cross-section of each would look like.

X.S. of model 1

X.S. of model 2

3.2 Now examine the following two micrographs of mitochondria from two different cells. In each case the mitochondria have been cut in cross-section. In **EACH ONE** label **inner membrane**, **outer membrane**, **cristae**, and **matrix**.

Which of the models above (1 and 2) do you think would produce the X.S. shown in each of the micrographs?



Model _____

Model _____

6. In what ways are mitochondria similar to chloroplasts, and how do they differ from them?

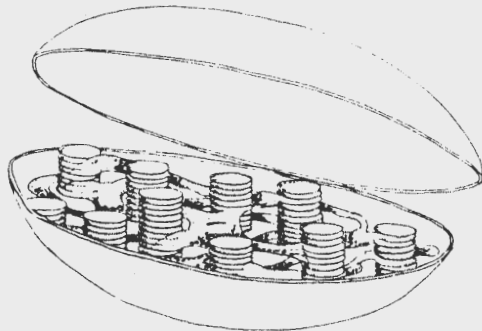
Similarities

Differences

7. Briefly state the function of mitochondria.

CHLOROPLASTS ARE 3-D

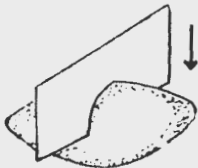
1. Carefully examine the following stereogram (3-D picture) of a chloroplast, which appears to have been cut length-wise, and the top half lifted off like a lid.



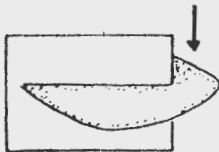
- 1.1 Label the following structures on your stereogram: outer membrane, inner membrane, stroma, granum, thylakoid, inter-granal lamella.

- 1.2 Which of the three planes of cutting (shown below) shows the plane through which the chloroplast was cut? _____

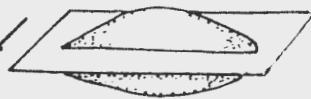
cross-cut



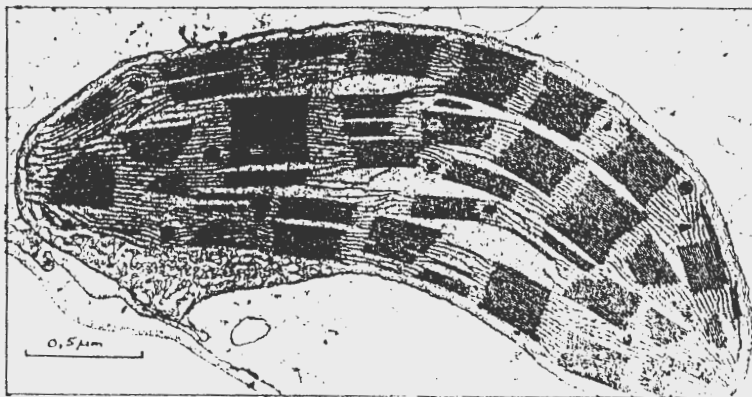
longitudinal cut in the plane of the page



longitudinal cut at right-angles to the plane of the page.



- 2.1 Carefully examine the following electron micrograph of a chloroplast. Compare it with the stereogram in question 1, and work out in which plane it must have been cut to produce a section which looks like this. _____



- 2.2 Label the following structures on the photo on the previous page:- Inner membrane, outer membrane, stroma, granum, thylakoid, inter-granal lamella.

- 2.3 Use the scale provided to work out the length and the width of this chloroplast.
length _____ μm width _____ μm

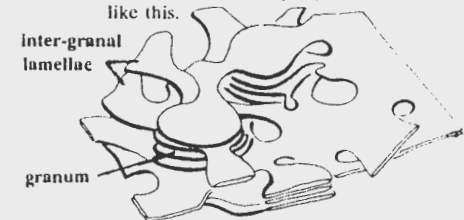
3. Use the pictures in questions 1 and 2 to help you to work out what a section would look like if a CROSS-SECTION was cut from the chloroplast. Pay particular attention to the outline shape of the chloroplast, and then to the structure of the grana and the inter-granal lamellae. Draw what YOU think the X.S. of the chloroplast would look like.

4. When biologists first obtained electron micrographs of chloroplasts, they were still trying to work out how the lamellae linked to the thylakoids in the grana. They had two theories, illustrated below.

Theory 1: there is an inter-granal lamella attached to every thylakoid, so it looks like this.

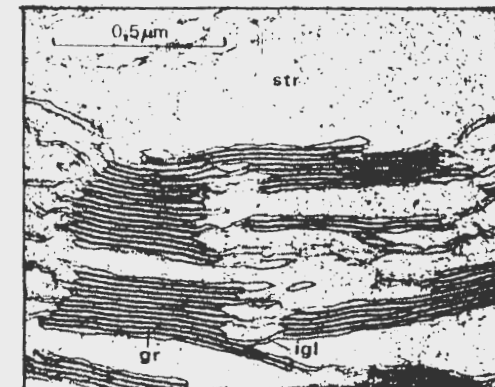


Theory 2: the lamellae branch and overlap, and are not arranged in parallel like this.



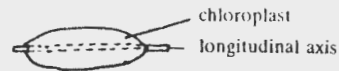
- 4.1 Examine the following micrograph, which shows part of a chloroplast very highly magnified. Use it to decide which of the two proposed theories (illustrated above) you think the photograph supports. Theory _____.

Justify (give reasons for) your answer.



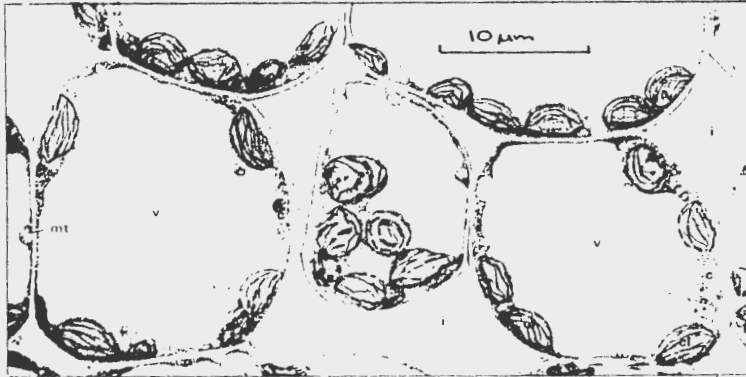
- 4.2 Identify the thylakoid, stroma, granum, and inter-granal lamellae.

5. This diagram represents the (imaginary) longitudinal axis of a chloroplast. Examine the arrangement of the lamellae in the pictures provided so far, and try to decide if the lamellae are arranged PARALLEL to the longitudinal axis, or AT RIGHT ANGLES to it. _____



NB: This is a major structural difference between chloroplasts and mitochondria.

6. This electron-micrograph gives you a good idea of the size of chloroplasts relative to the spinach leaves in which they occur.



- 6.1 Label a chloroplast in your picture.
- 6.2 Why does the cell appear almost empty, with the chloroplasts squashed against the cell wall?
- 6.3 Use the scale provided to estimate the length of the largest chloroplast you can see. _____ μm. Now work out the length of the cell it is in. _____ μm.

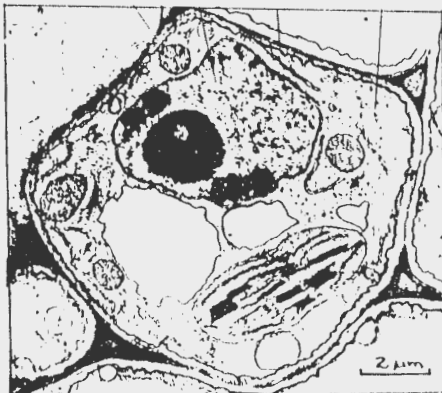
7. Briefly state the functions of
a) chloroplasts

b) the other types of plastids you have learned about.

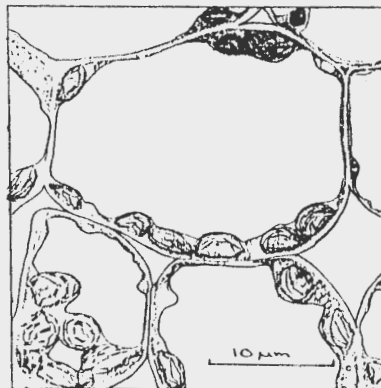
VACUOLES are 3-D

1.1 Label the **vacuole** and the **tonoplast** in each of the following micrographs.

picture 1



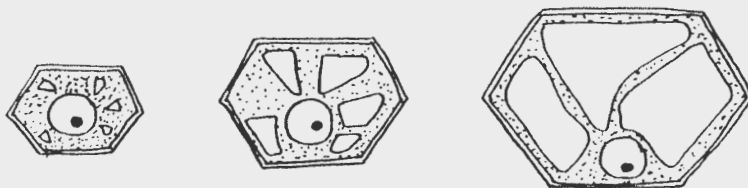
picture 2



1.2 Use the scale provided in each photograph to measure the length of the largest vacuole in each cell. Indicate the length on the photograph in each case.

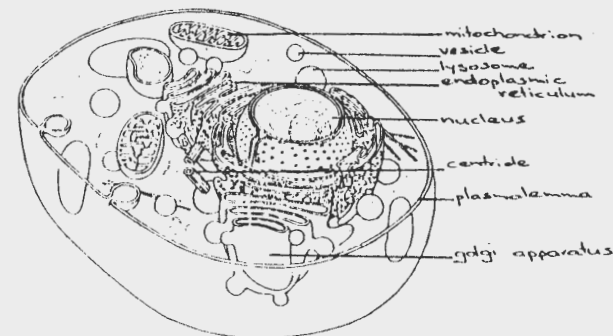
1.3 How many vacuoles are there per cell, in picture 1 _____ and in picture 2 _____?

1.4 Use the following sketches to try to work out what happens to a plant cell as it matures. Explain your theory.

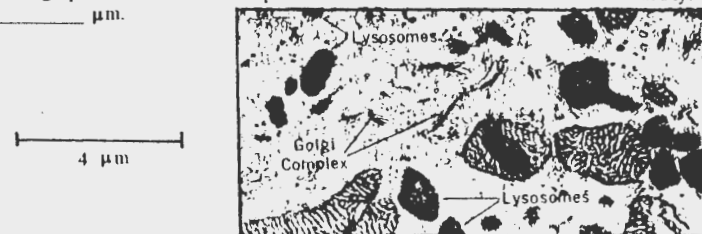


2.1 How do the vacuoles in a plant cell differ from those in an animal cell?

2.2 The vacuoles of animal cells are usually called vesicles. They often form by being pinched off from the membrane of other structures. Carefully examine the following 3-D representation of an animal cell, and list **TWO** structures which appear to be pinched off to produce vesicles (vacuoles). HINT: First decide whether the vesicles attached to the plasmalemma are being pinched off from the membrane or if they are fusing (joining) with it.



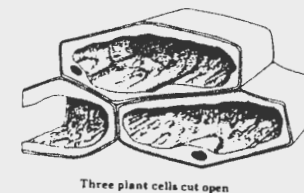
3. The vesicle often encloses digestive enzymes, and becomes a lysosome. Locate the lysosomes in the electron-micrograph below. Use the scale provided to estimate the size of the medium-sized lysosomes shown. _____ μm.



4. Briefly state the functions of vacuoles

a) In plant cells

b) In animal cells



Three plant cells cut open

Thinking in 3-D: Brain-teaser No. 2
(the cell super-sleuth)

A new and deadly germ attacks the population of Johannesburg, causing horrific symptoms such as greening of the complexion and a sudden devotion to university work (to the exclusion of all else). The disease proves fatal for several students, who work too hard and forget to sleep and eat.

There is mass panic among the population, and doctors ask a group of dedicated biologists to investigate the germ in order to discover more about its structure and how it attacks and affects the human body, so that some cure can be sought.

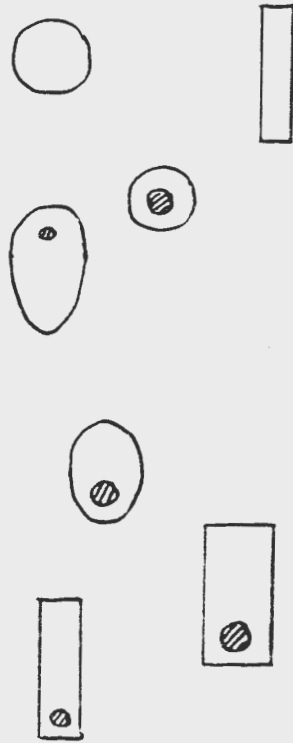
The biologists who have been given the task of investigating the **structure** of the germ are lucky enough to obtain a large supply of infected tissue, which has totally disintegrated into a pulpy mass, but which contains several of the germ cells. The cells are so tiny that they are hardly visible, even using the most powerful microscope known to man.

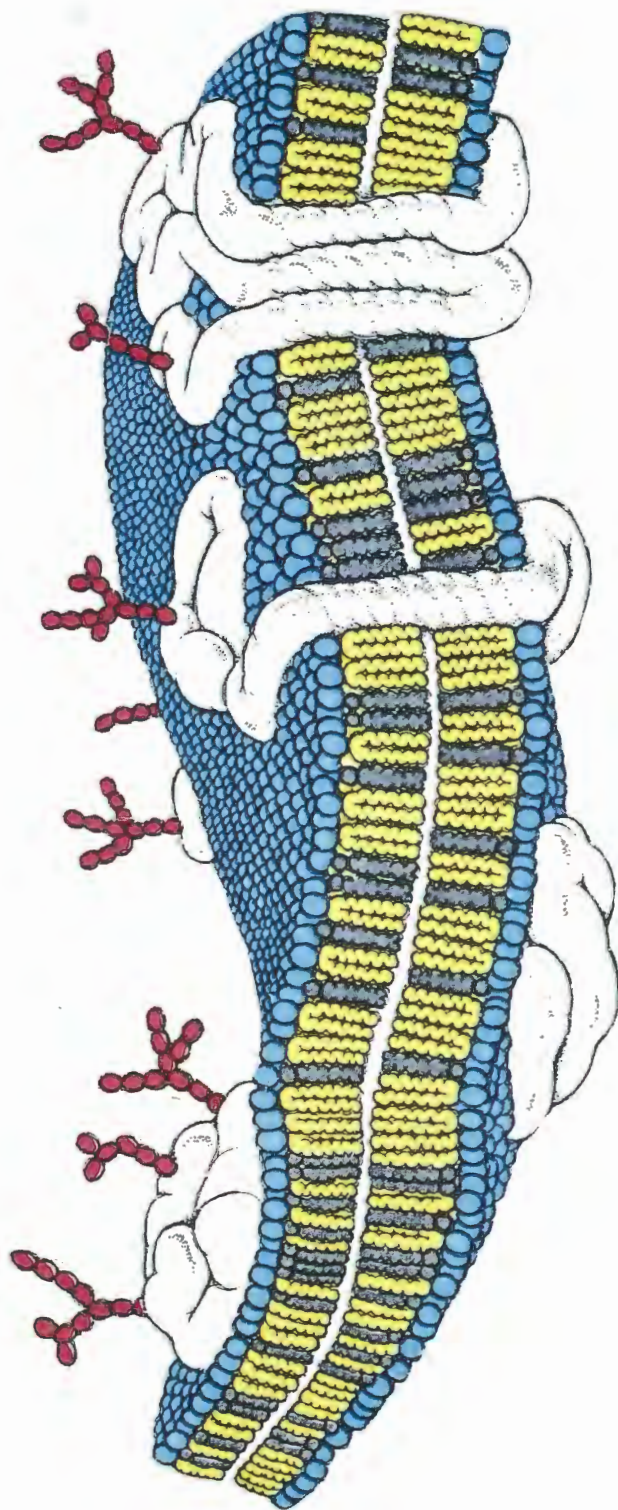
However, the intrepid biologists, slaving long into the night, selflessly risking their own health and sanity, are able to cut many sections, at every angle, and take several electron micrographs (shown below) of the cell. They must now use the information they have obtained to work out the 3-D structure of the germ.

Examine the sections they obtained, and see if you can work out what the germ looks like in 3-D. Produce a 3-D sketch to show your theory.

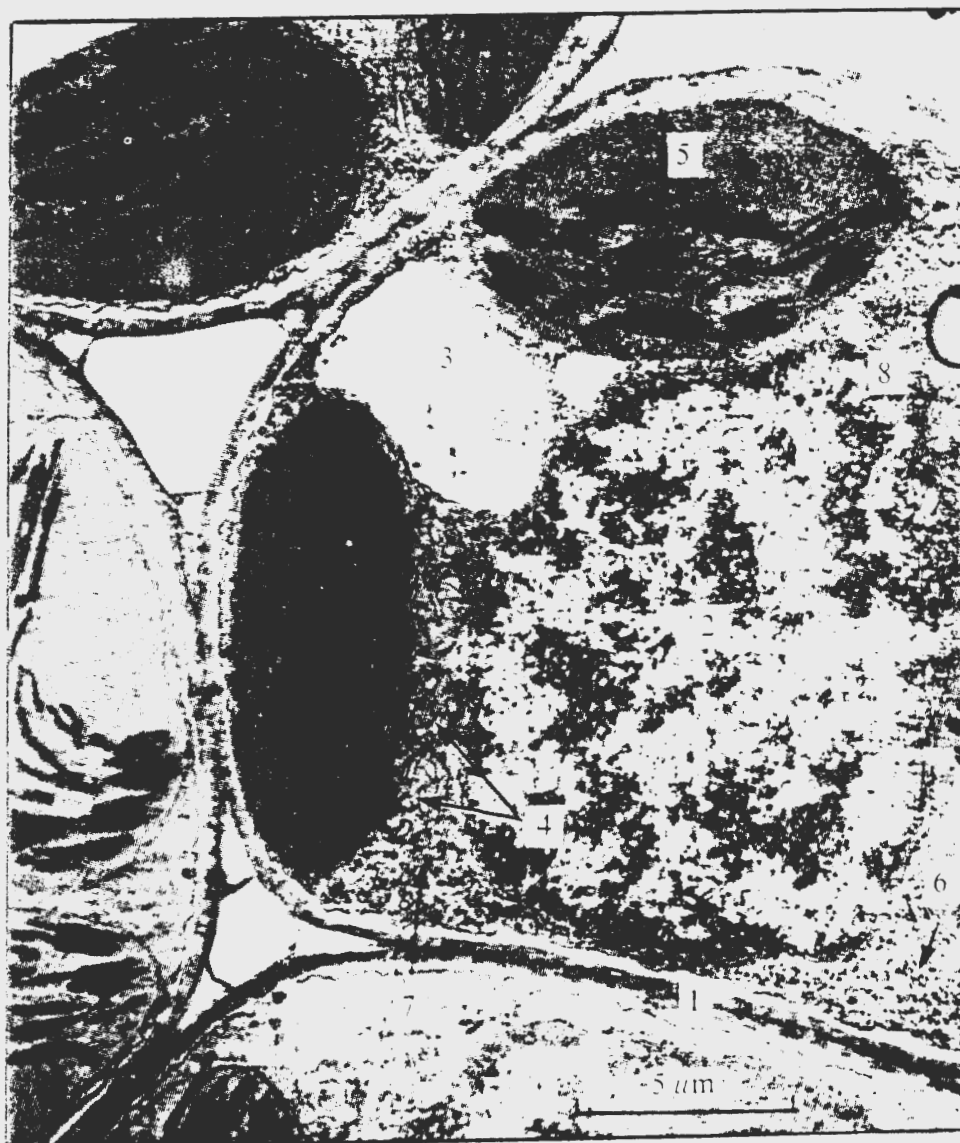
Several sections from the same germ cell

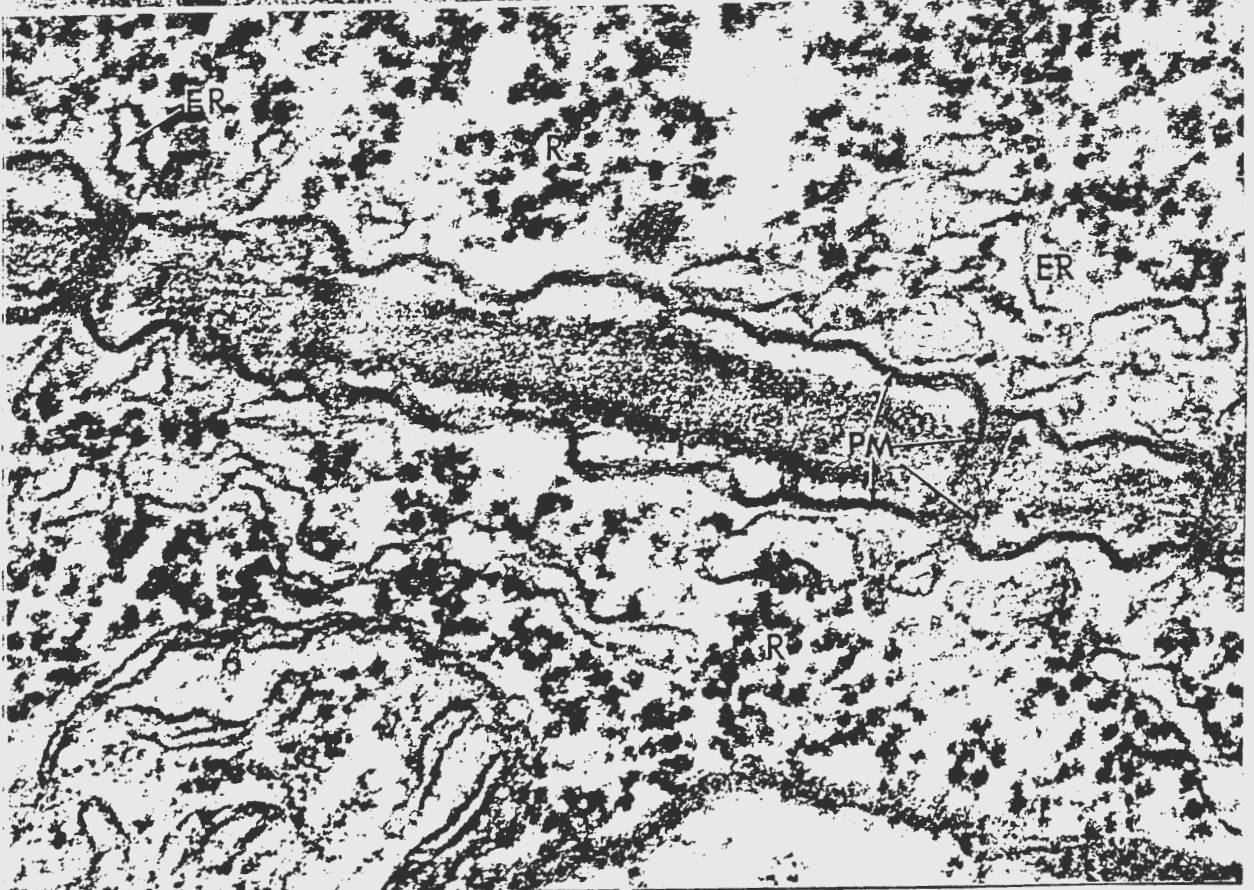
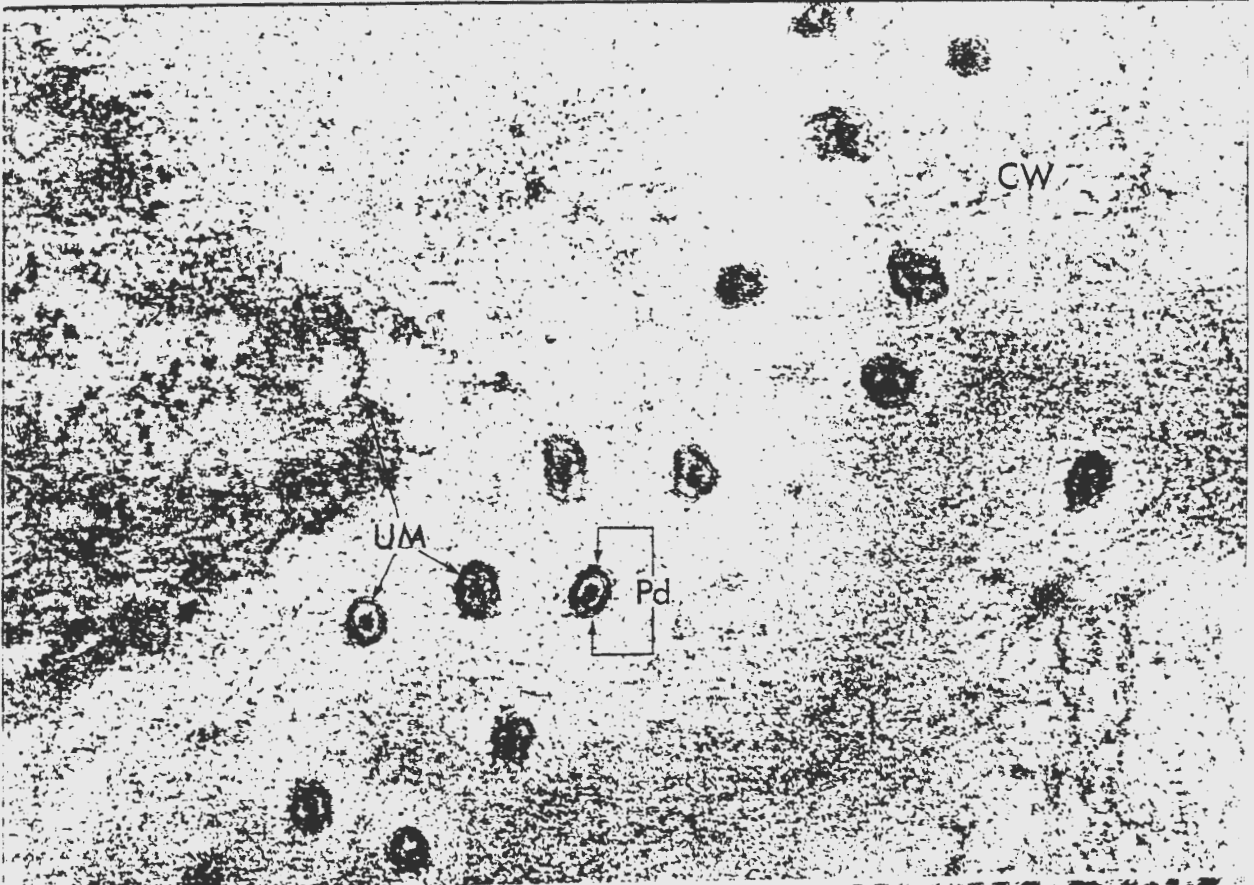
Your diagram of the germ

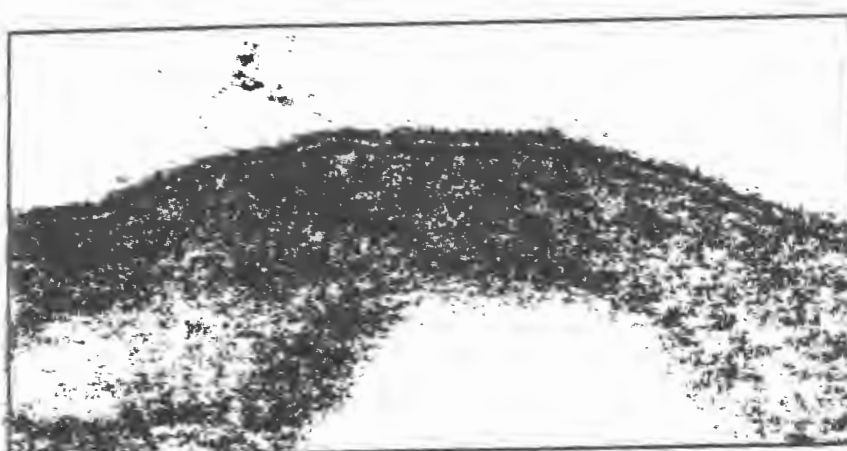
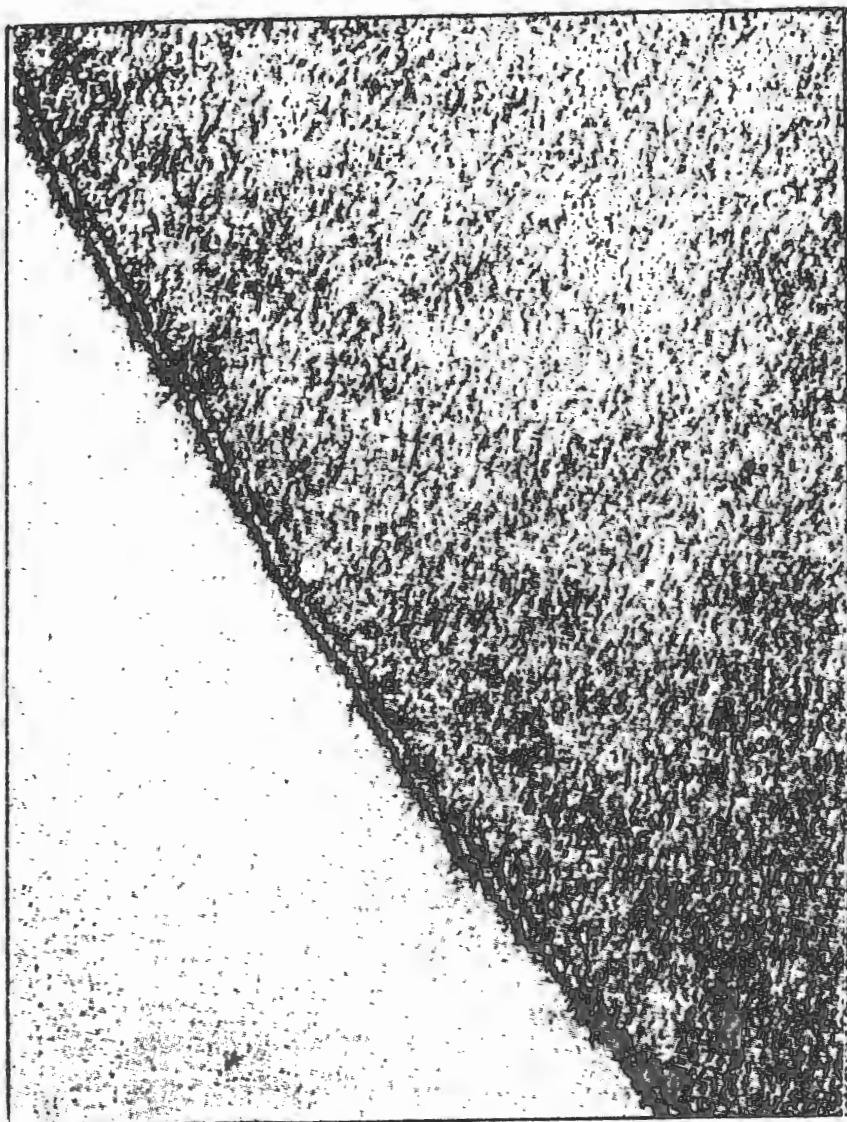


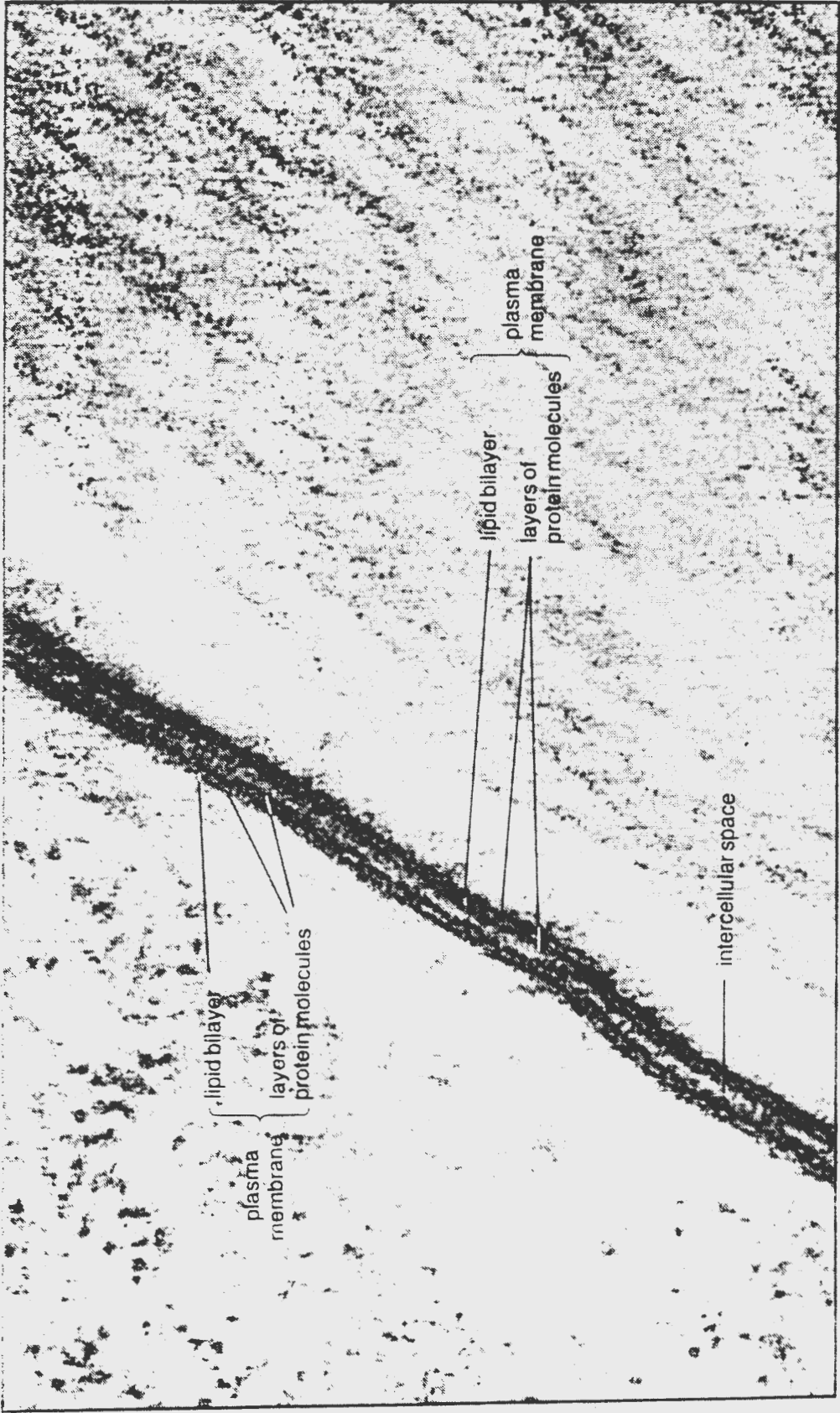


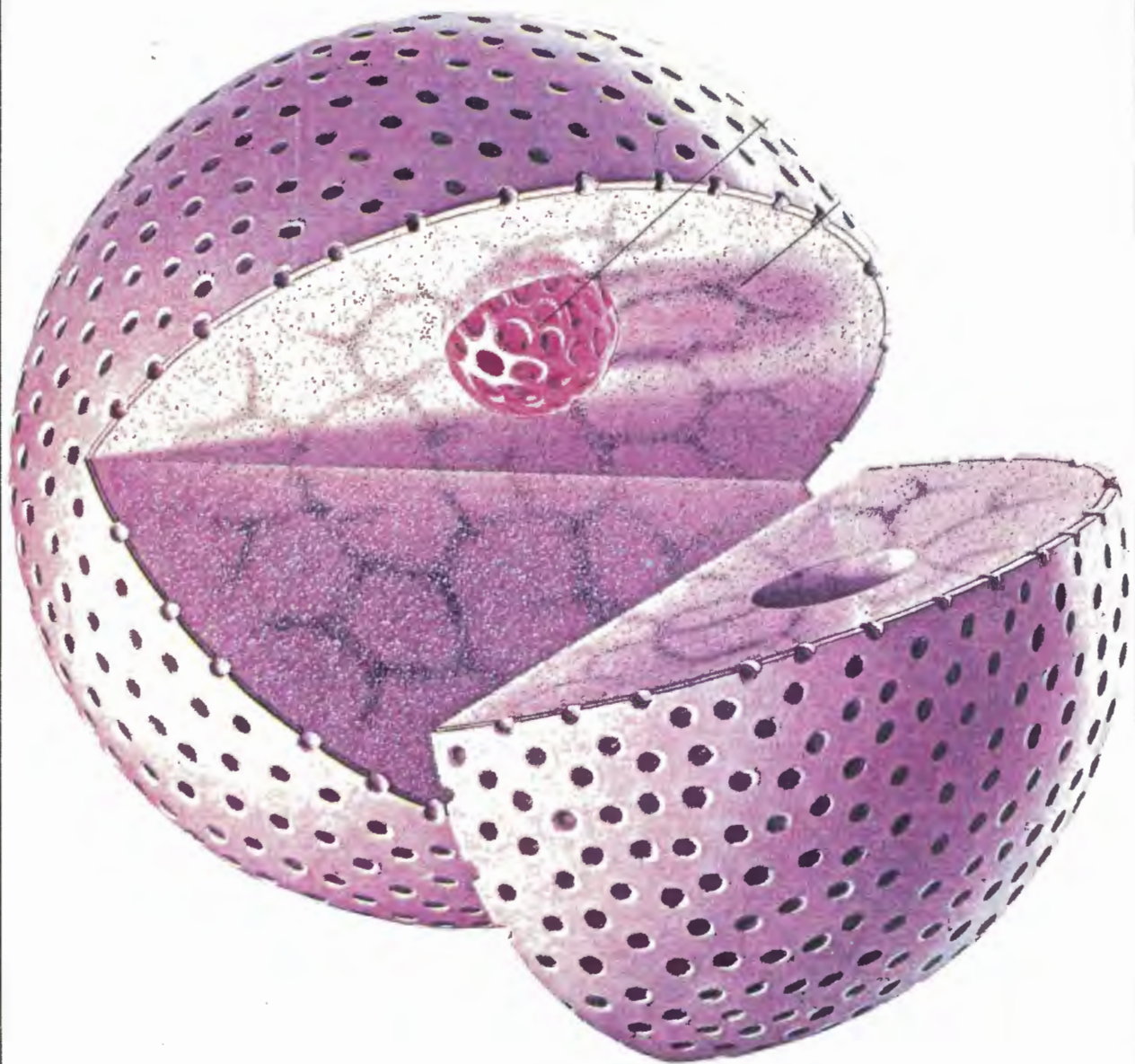


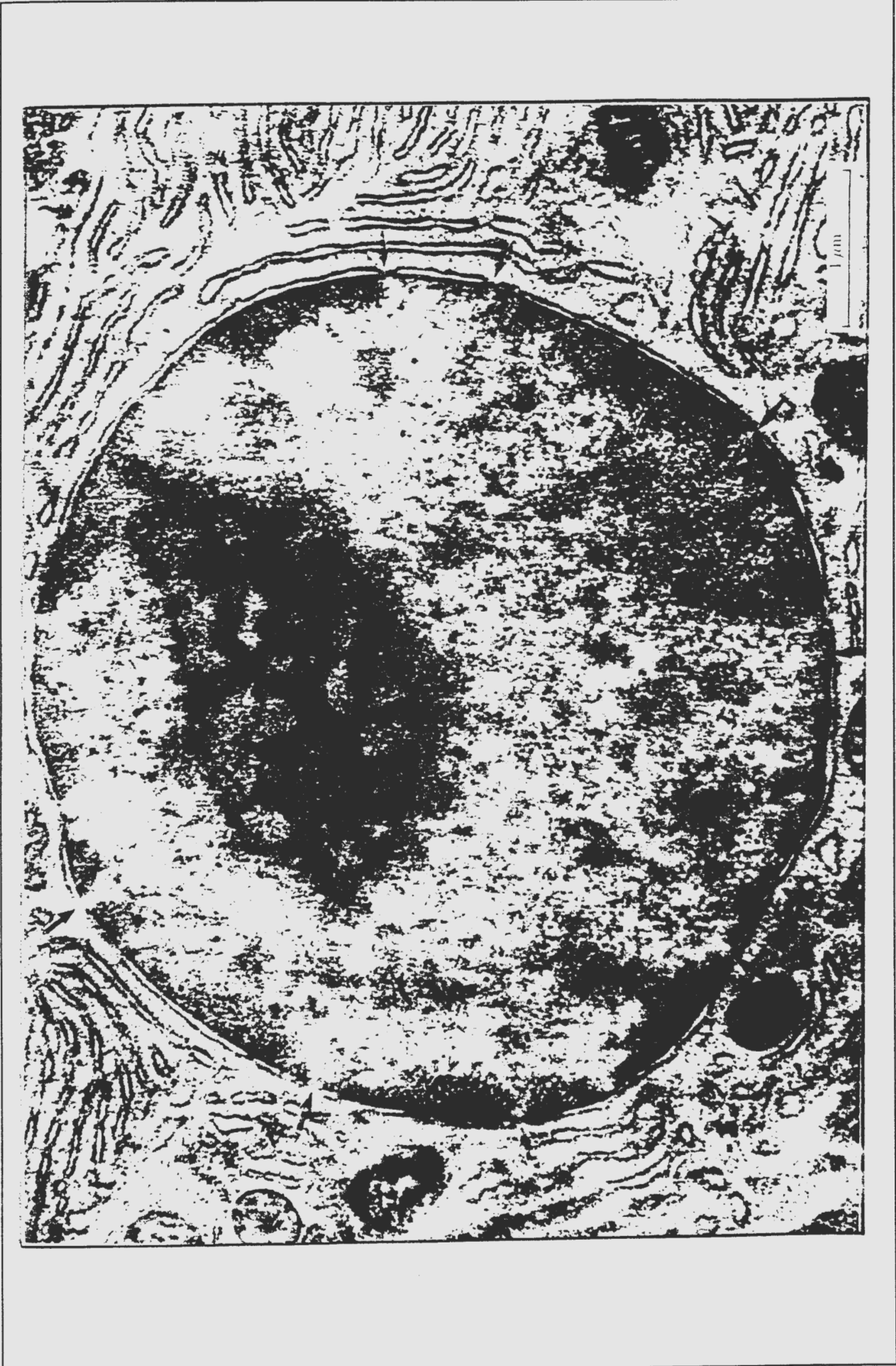


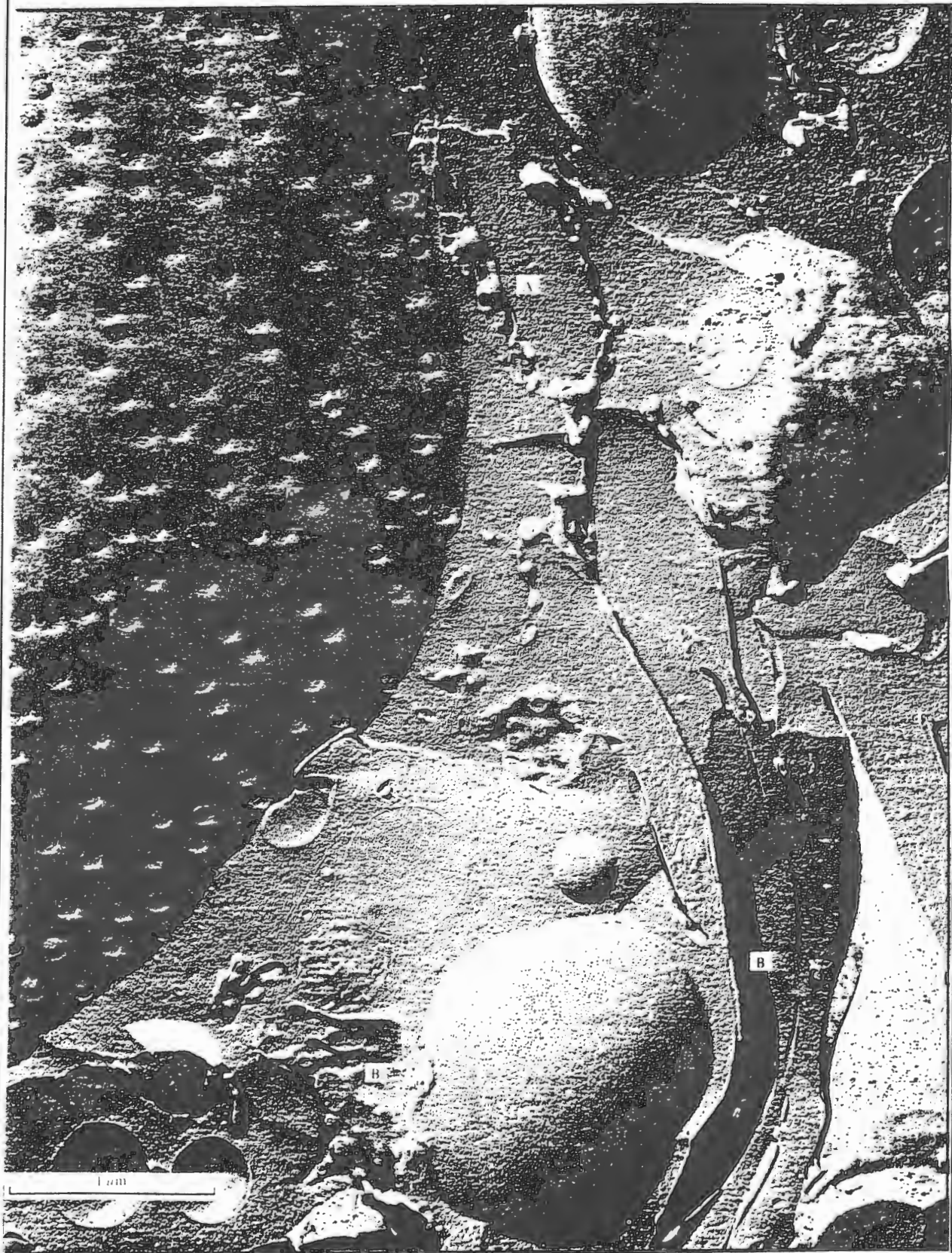


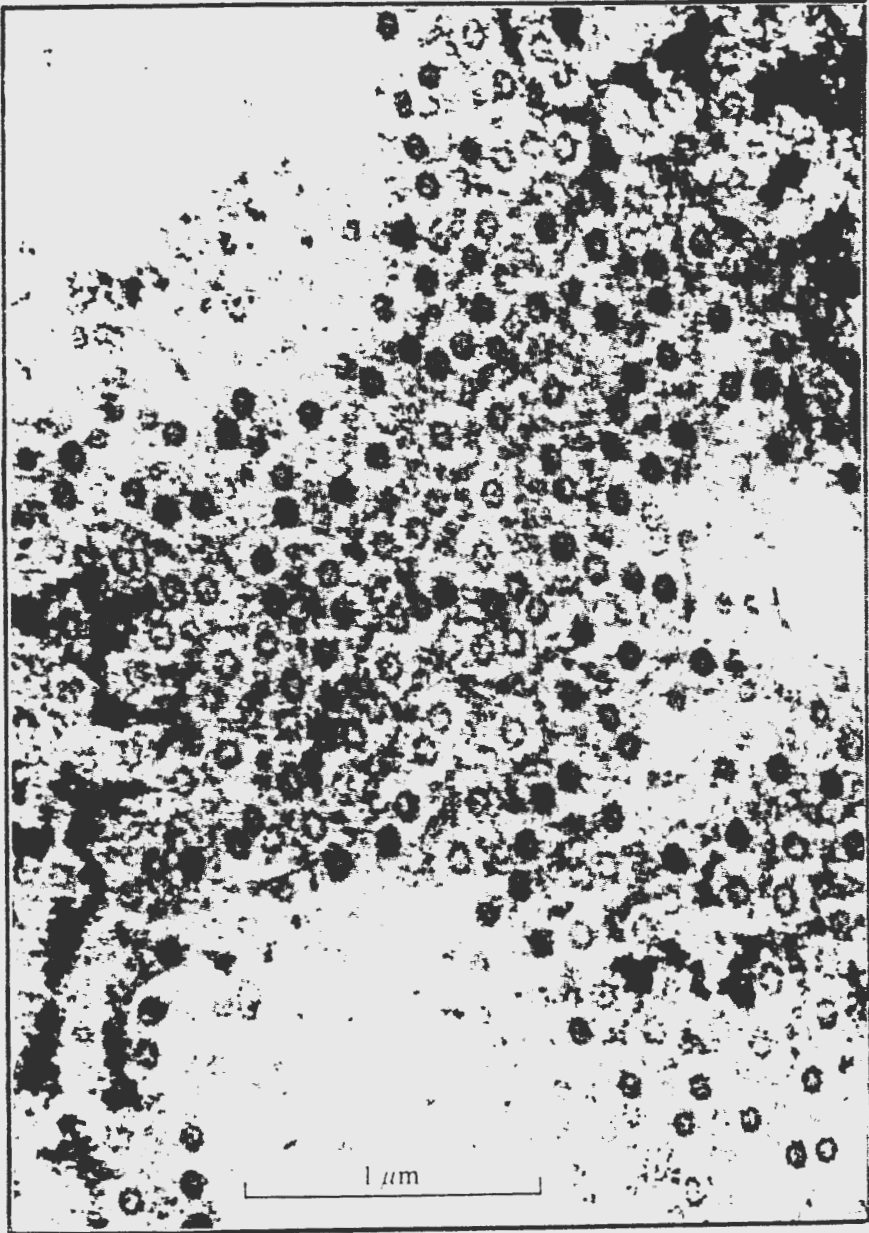


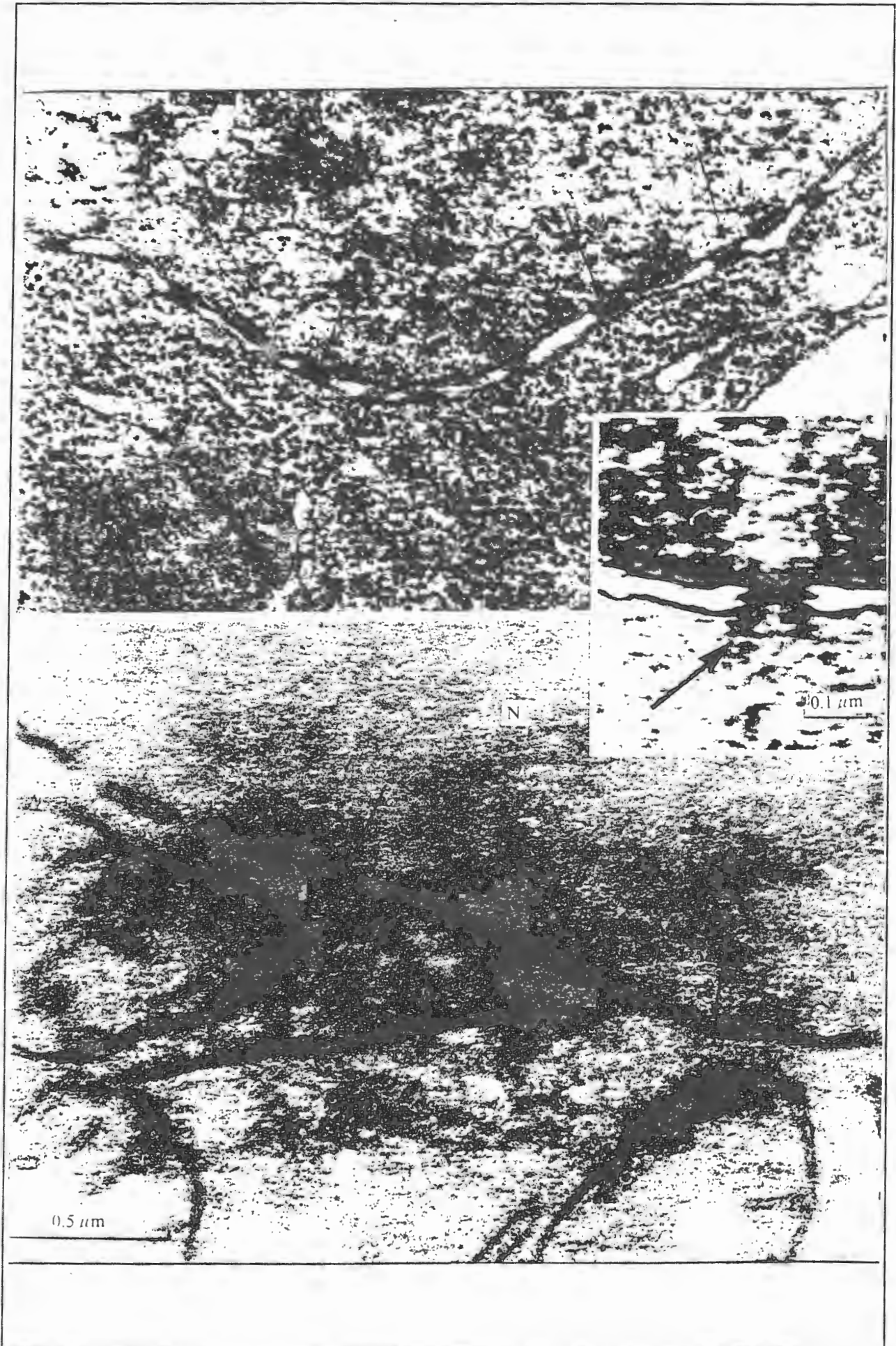




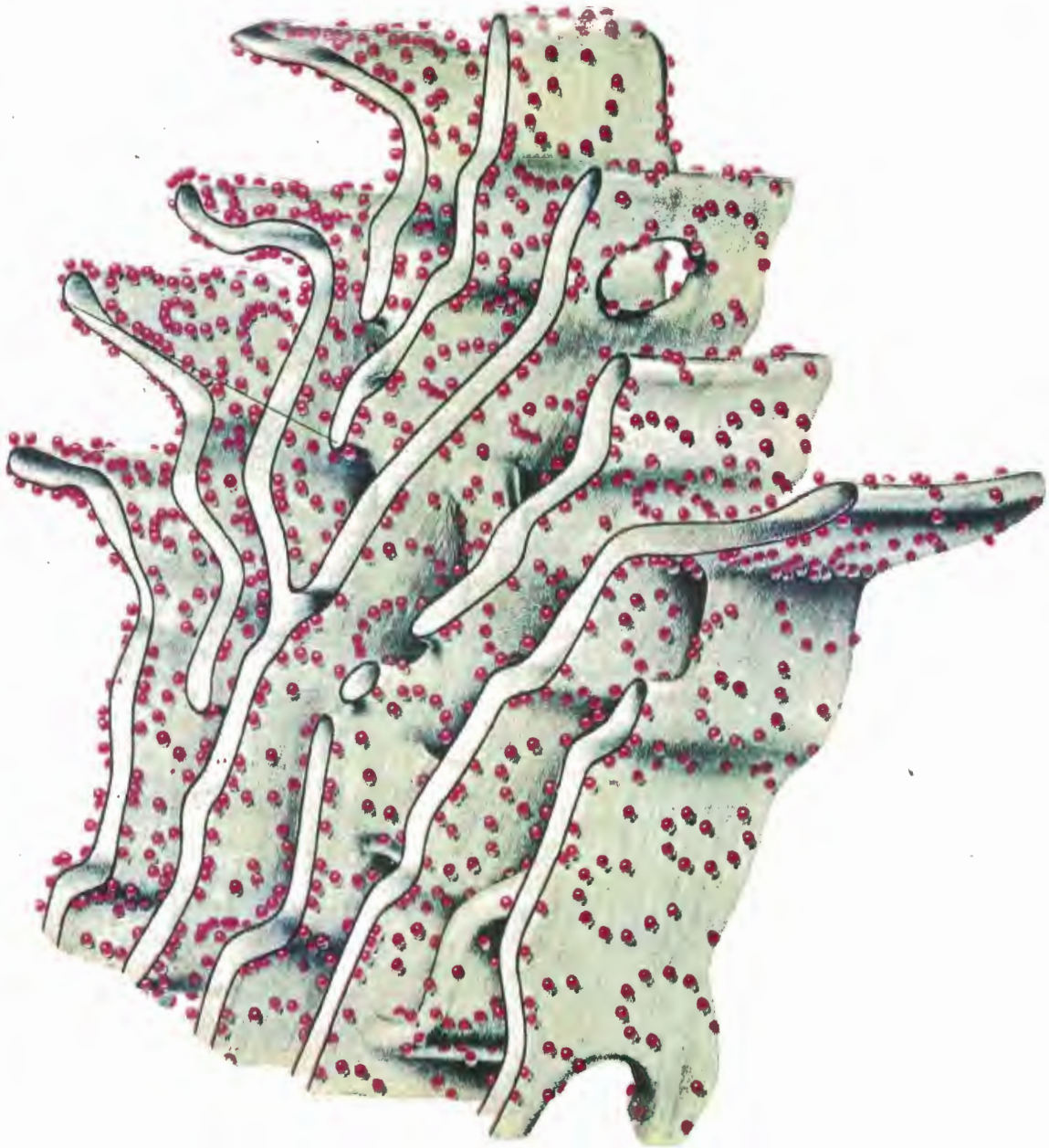


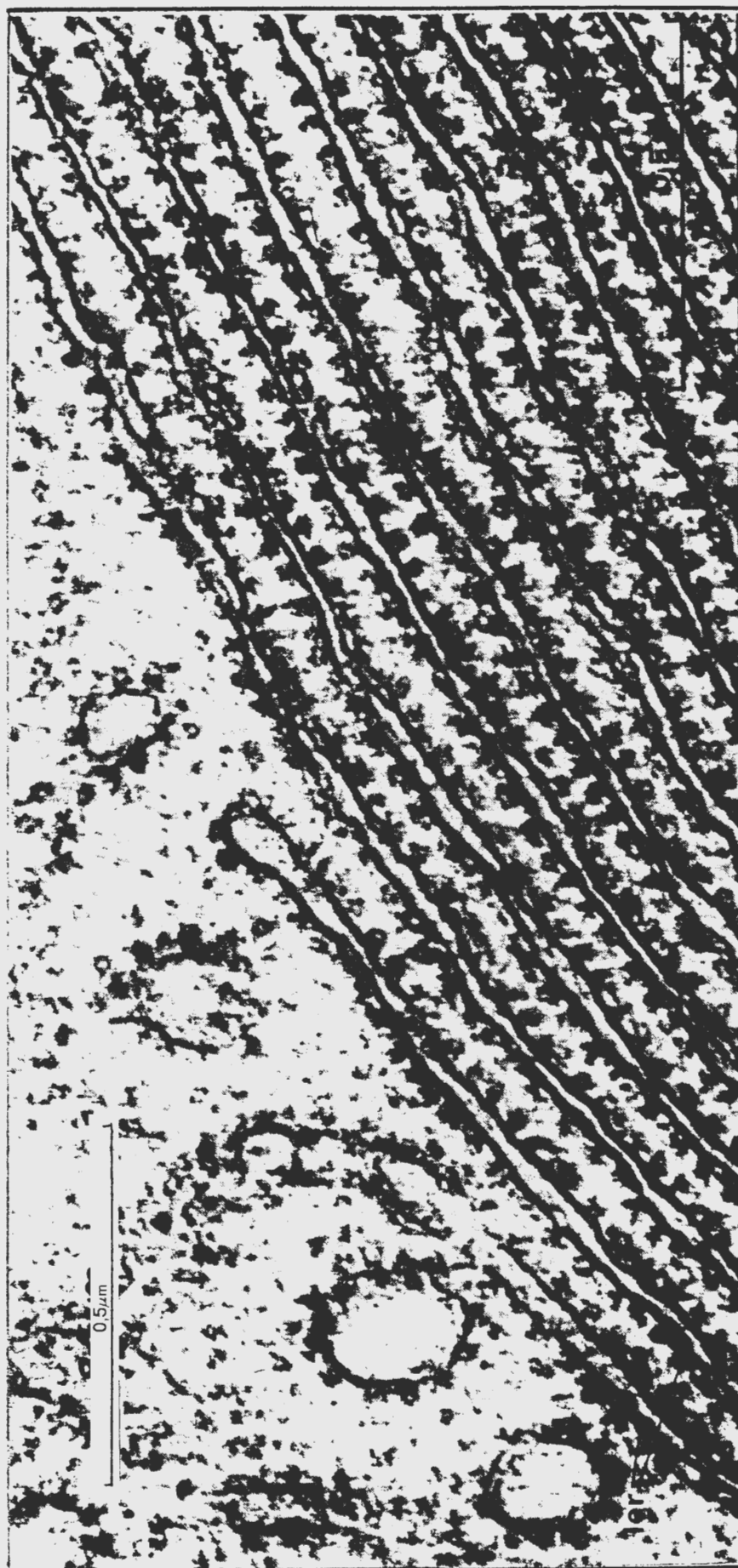


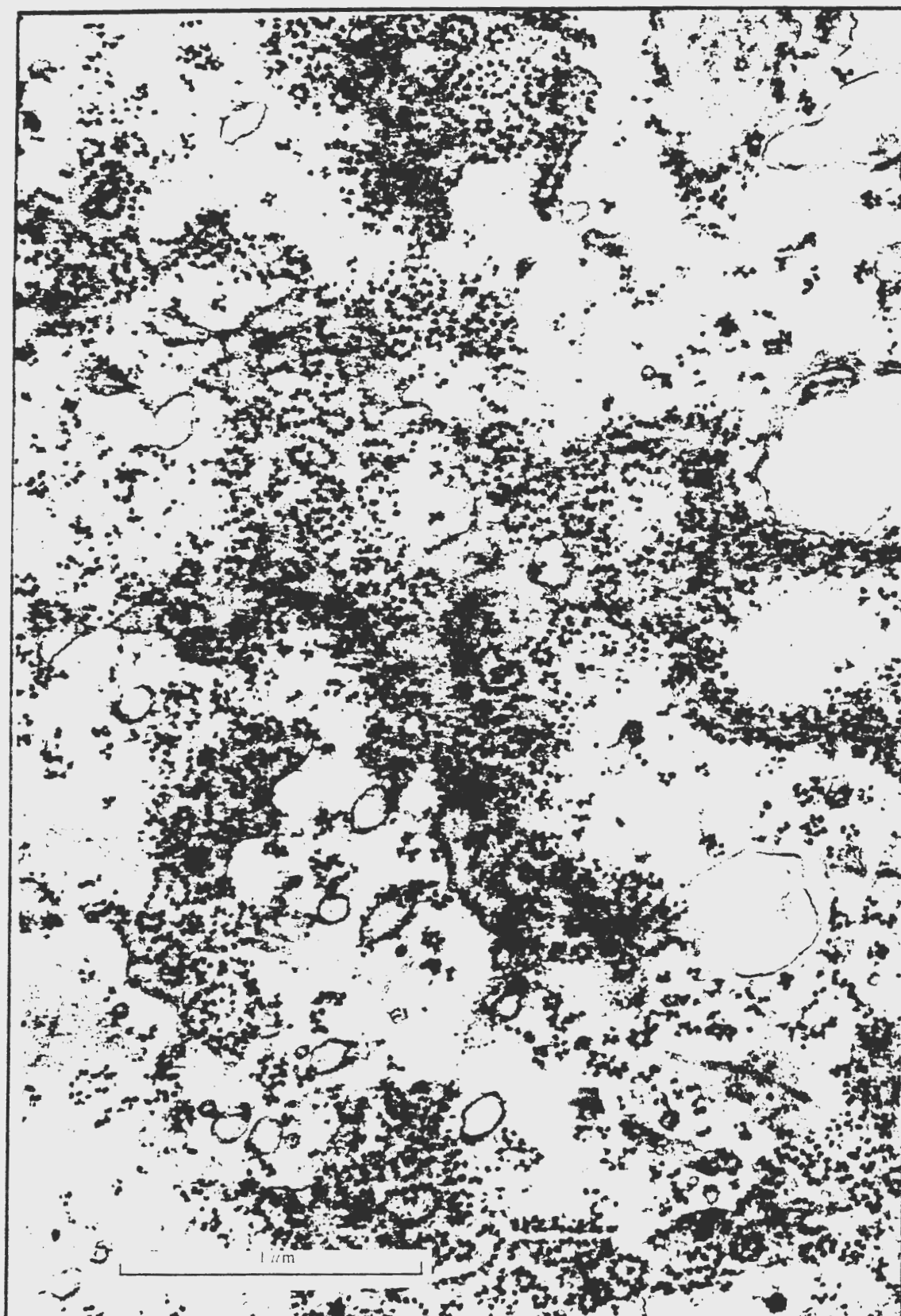




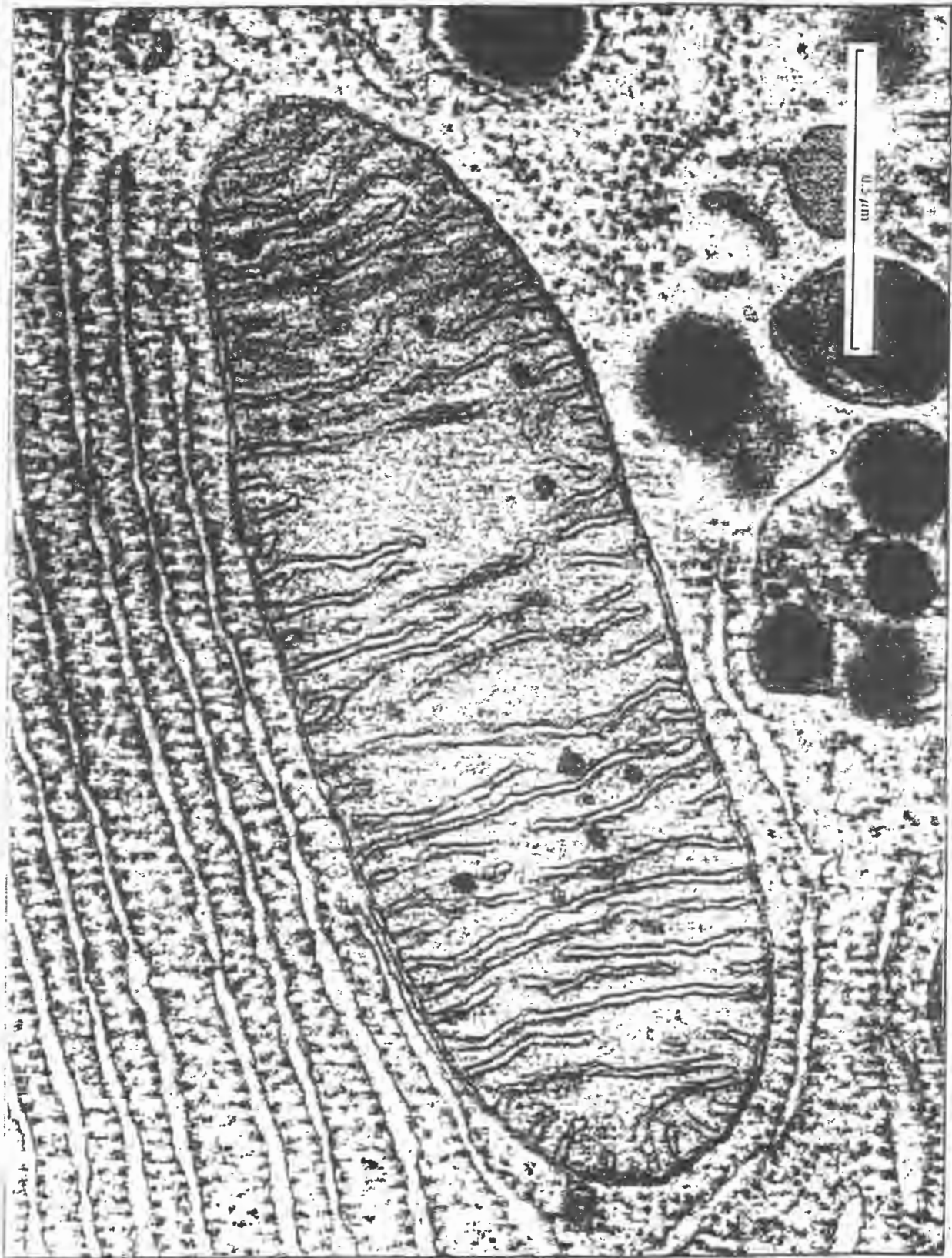








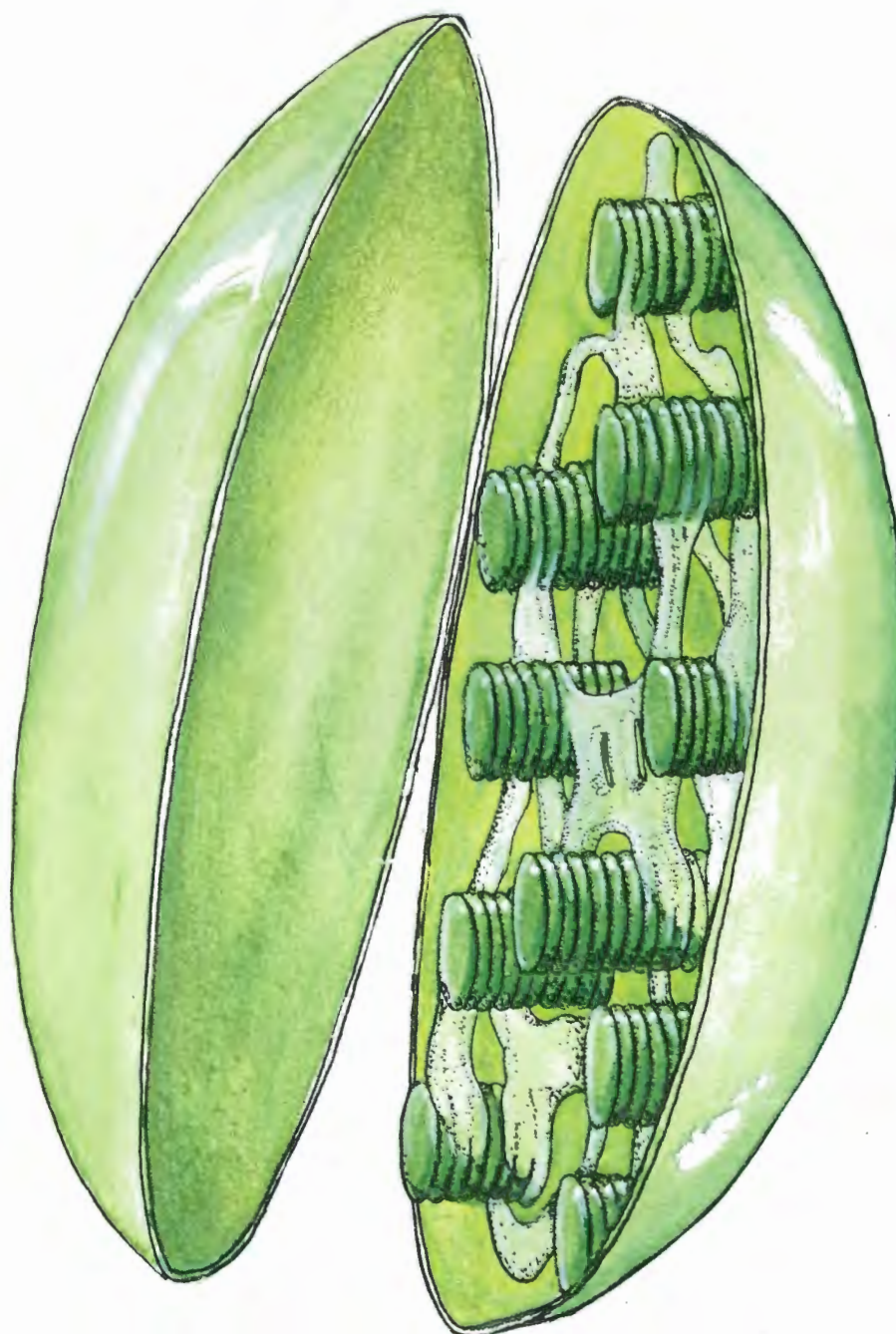


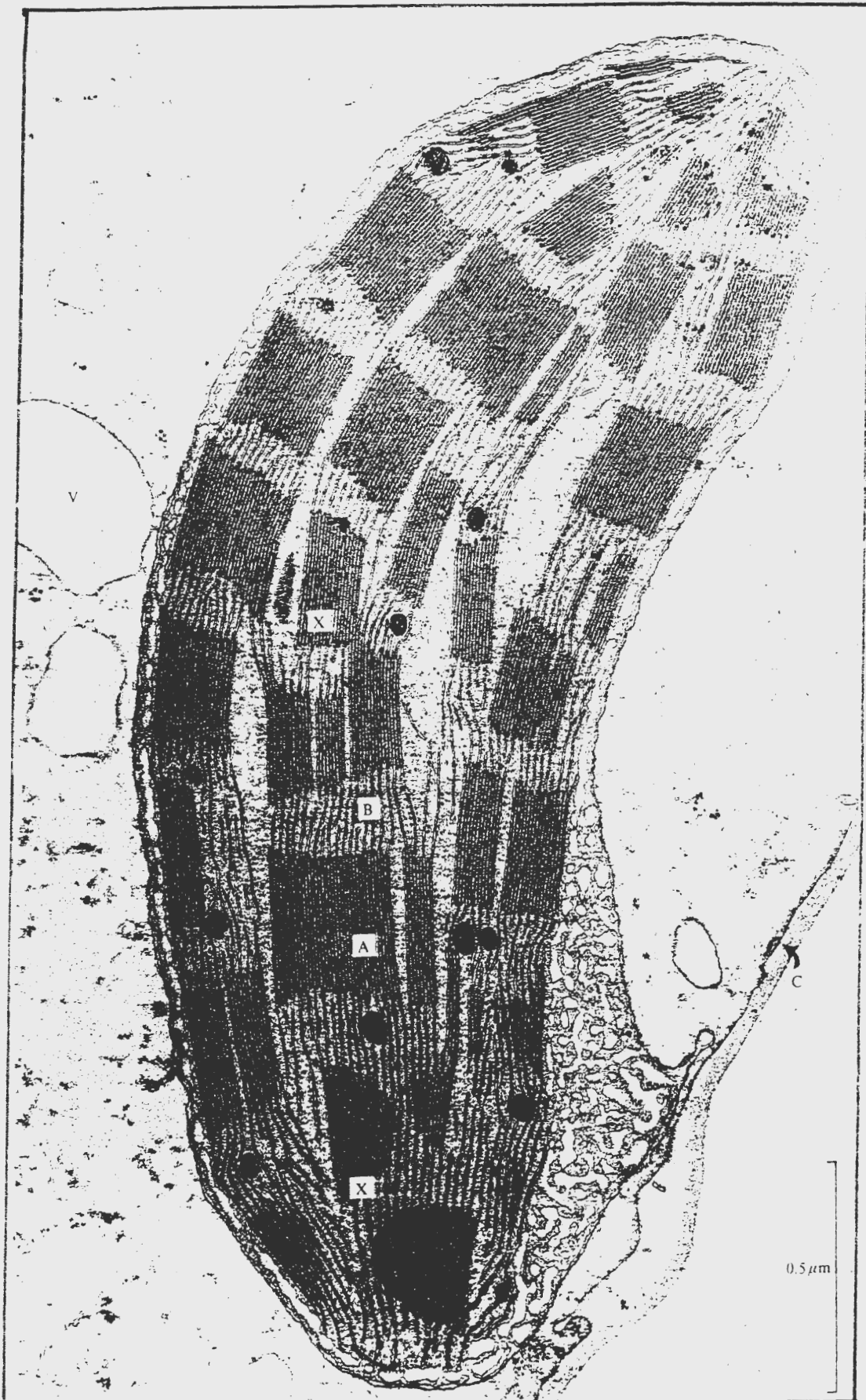


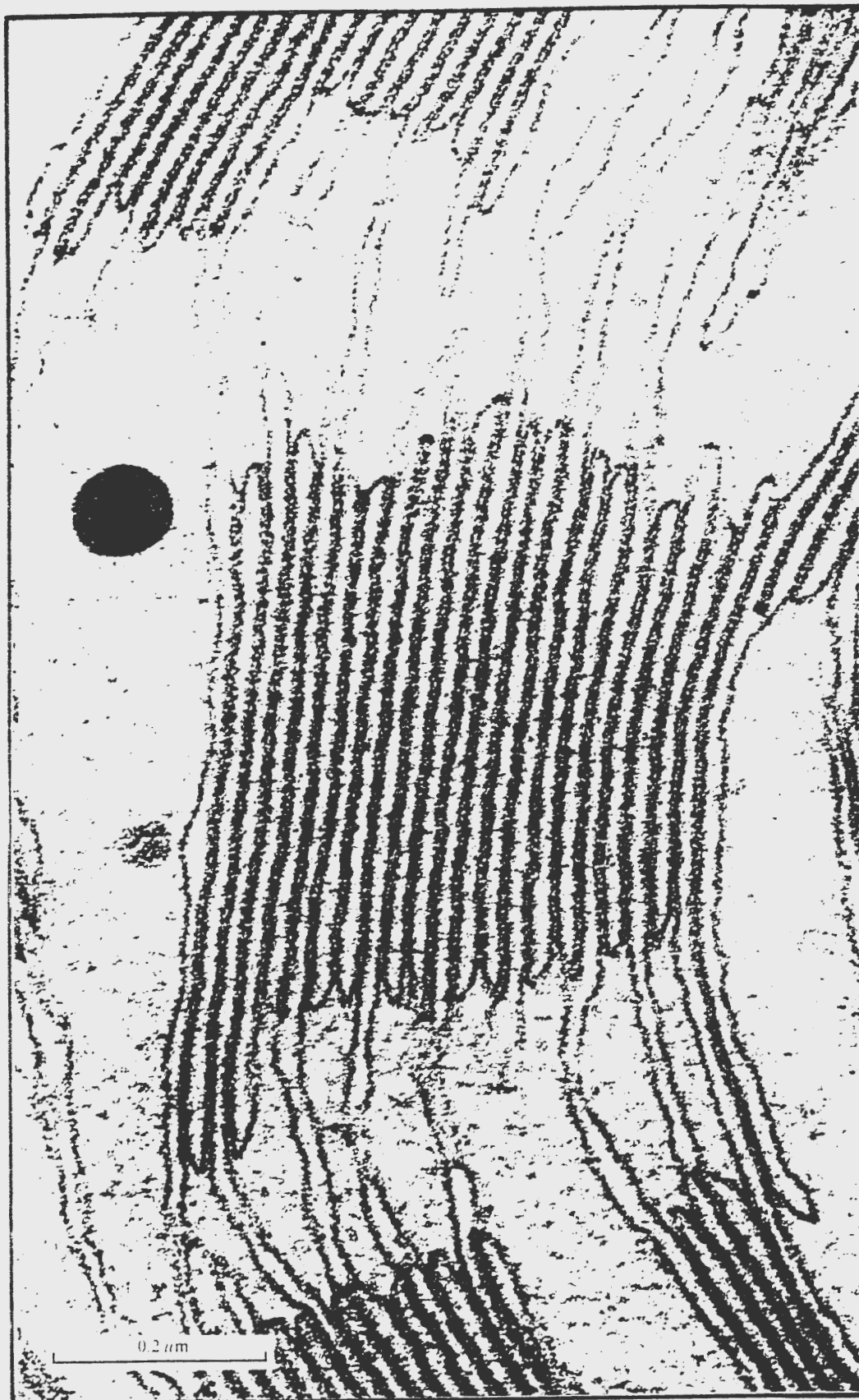


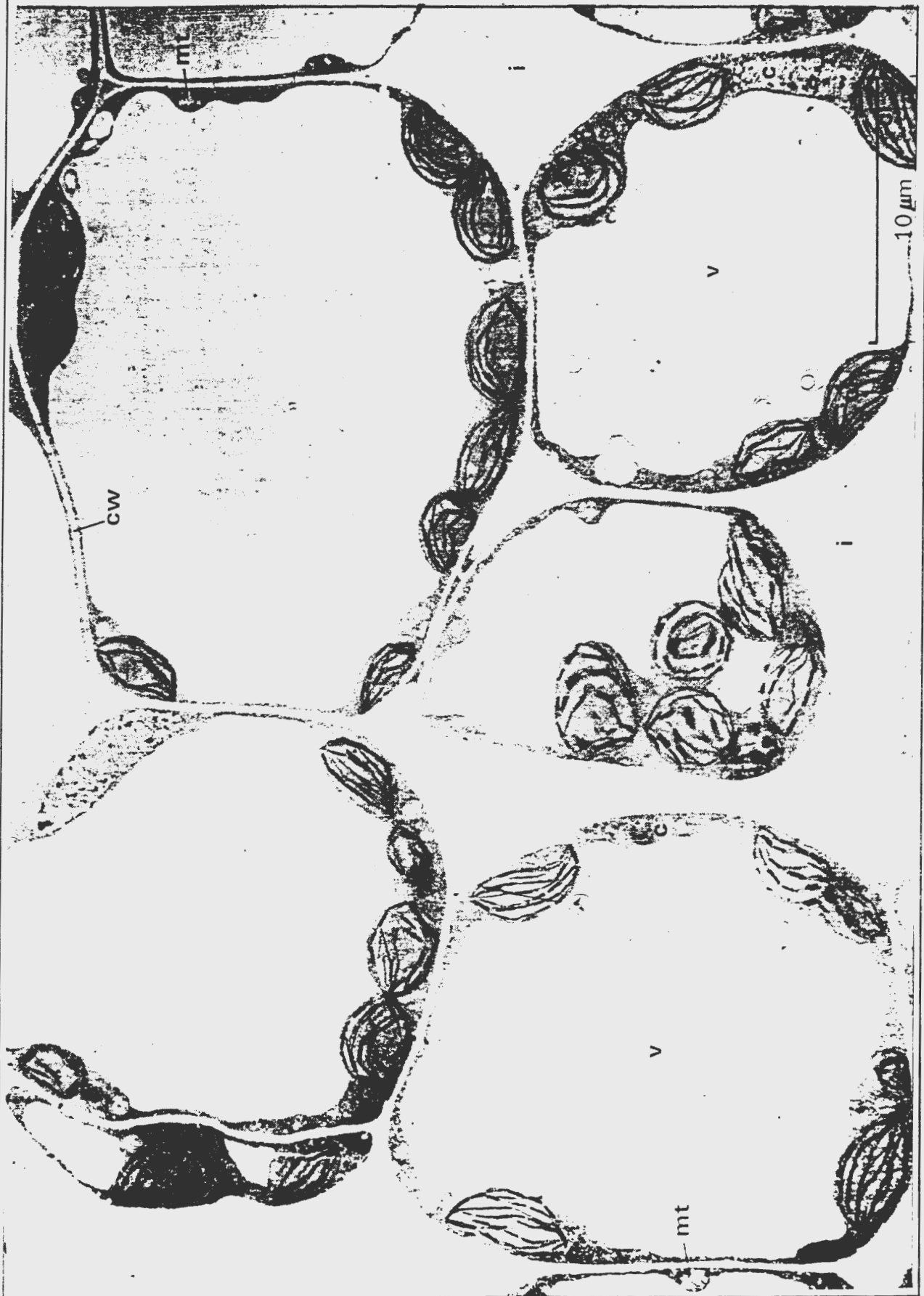
LESSON 6 AND FURTHER LESSONS: Workcards for small group work

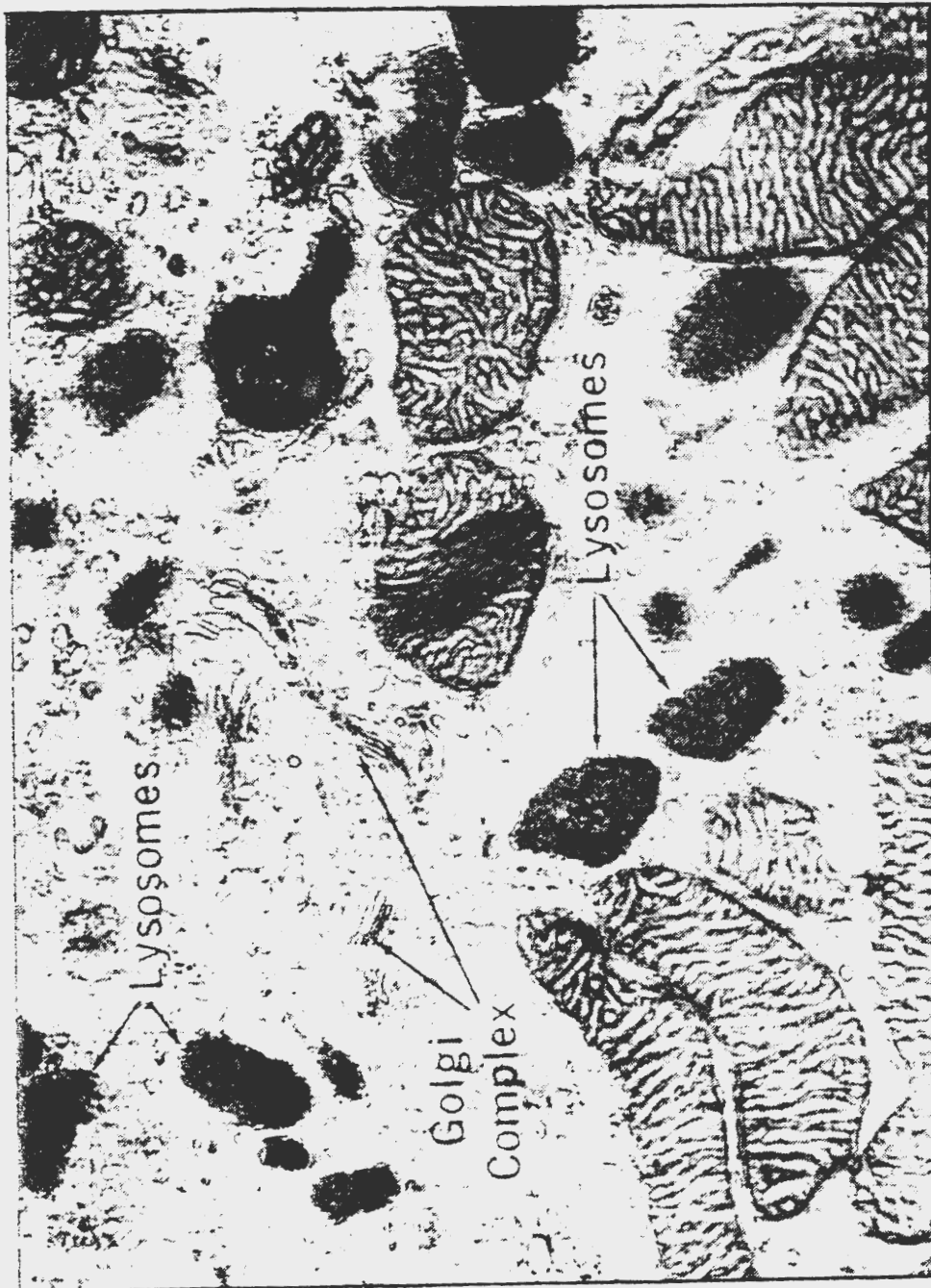


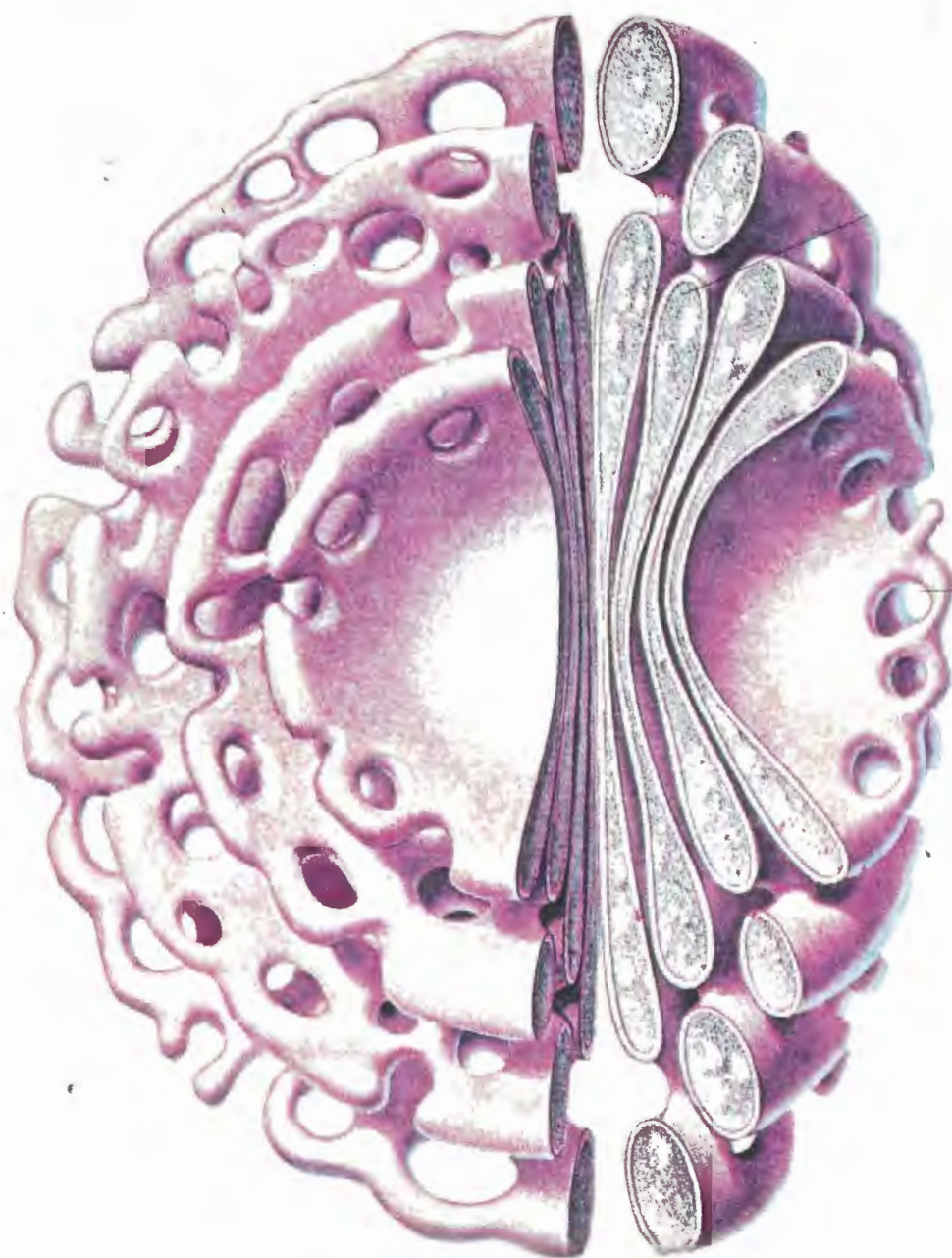




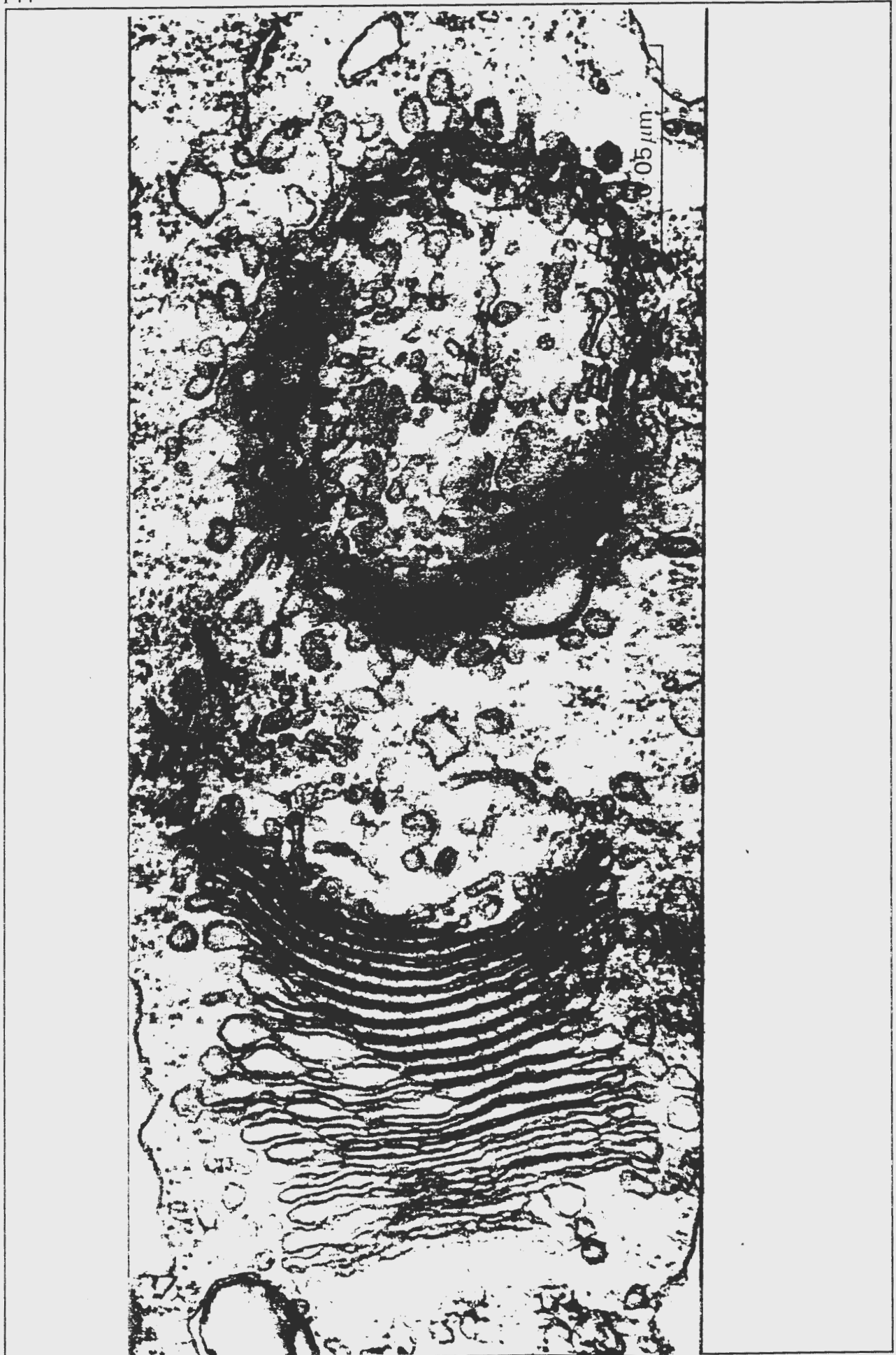


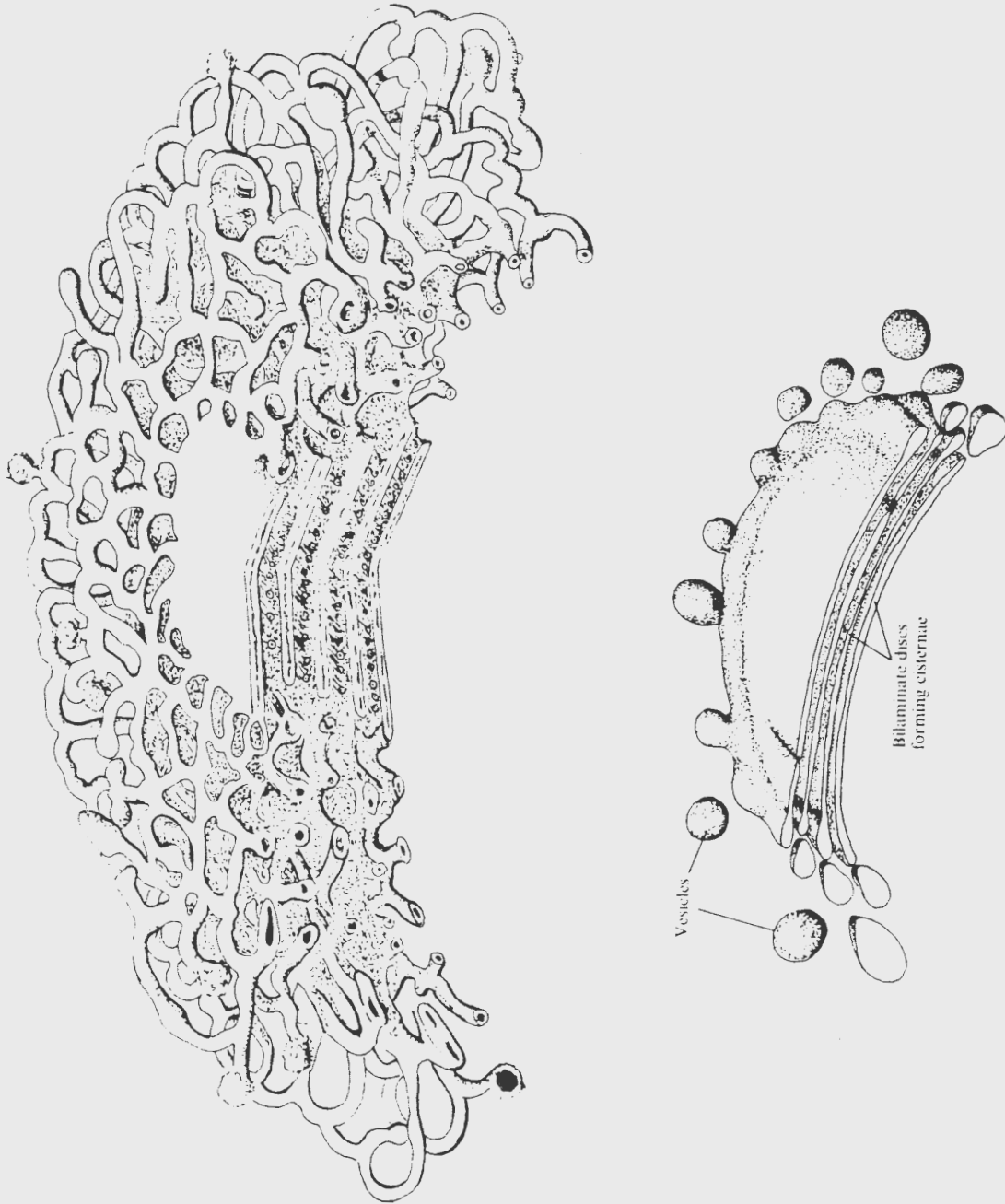












Thinking in 3-D: Brain-teaser No. 2

(the cell super-sleuth)

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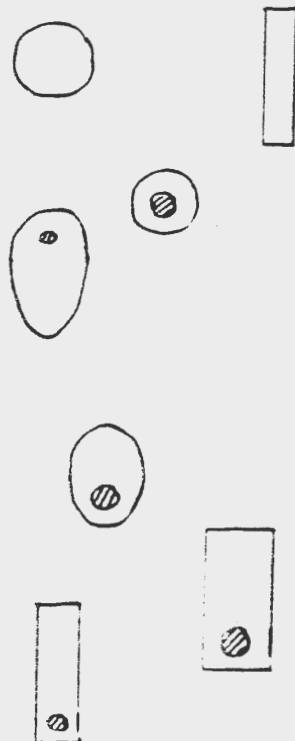
There is mass panic among the population, and doctors ask a group of dedicated biologists to investigate the germ in order to discover more about its structure and how it attacks and affects the human body, so that some cure can be sought.

The biologists who have been given the task of investigating the **structure** of the germ are lucky enough to obtain a large supply of infected tissue, which has totally disintegrated into a pulpy mass, but which contains several of the germ cells. The cells are so tiny that they are hardly visible, even using the most powerful microscope known to man.

However, the intrepid biologists, slaving long into the night, selflessly risking their own health and sanity, are able to cut many sections, at every angle, and take several electron micrographs (shown below) of the cell. They must now use the information they have obtained to work out the 3-D structure of the germ.

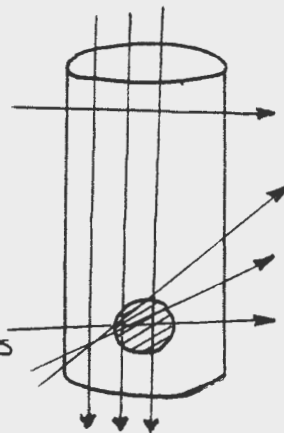
Examine the sections they obtained, and see if you can work out what the germ looks like in 3-D. Produce a 3-D sketch to show your theory.

Several sections from the same germ cell



Your diagram of the germ

possible
structure of
germ, showing
where sections
were cut



ACCURATE OBSERVATION AND DRAWING

**A teaching and learning package for Std 8 Biology
in South African schools**

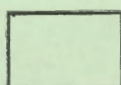
(The cell)

*Developed by Martie Sanders
Department of Botany
School of Science Education
University of the Witwatersrand
P O WITS
2050*

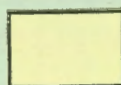
Telephone 716-4010 (W) 787-9288 (H)

WHAT'S WHAT

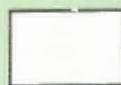
The pages in this file have been colour-coded to help you to find your way around.



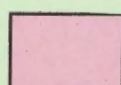
Introductory comments



Teacher's notes on lessons



Teaching resources



Teacher's record of work

WHY USE THIS PACKAGE?

Thank you for agreeing to participate in this research study, which is examining ways in which educators can help biology pupils to understand biological drawings and the 3-D structures they represent. In particular, I am interested in helping them to understand diagrams of biological sections and the whole structures from which they are cut.

A teaching package has been produced which emphasises that living things are 3-D, and that biology teachers need to adapt their teaching methods to highlight this fact and help their pupils to cope with spatial problems they may experience in understanding the 3-D nature of biological structures.

Two schools (termed the "experimental schools") are using this package when they teach their Std 8 pupils the section on the cell. A further two schools (where teachers realise the problems faced by biology pupils in understanding biological sections, and where the teachers have been enthusiastic about the research materials produced) have agreed to follow a **different** package, so that their schools can be used as "controls" in trying to assess whether the experimental treatment can help pupils understand biological sections. These schools will be presented with a complimentary copy of the experimental (spatial) materials once the research is completed, so that they can use it in future years.

NB: It is vitally important that the pupils do not know that they are a control group, or that other schools are doing a DIFFERENT package.

Your school was one of the two schools (of the four participating in the study) which was randomly selected to act as a "control" group. You will be using a teaching approach which emphasises the importance of accurate observation and drawing skills, and which sets out to develop these skills in the pupils. You are probably aware that many South African pupils struggle to produce accurate drawings of the specimens they are shown in biology. It is hoped that by teaching the pupils to **OBSERVE MORE CAREFULLY** and to **DRAW MORE ACCURATELY WHAT THEY SEE**, the quality of their drawings will be much improved.

The two "experimental schools" will be using a package which emphasises the 3-D nature of living things. Their teaching package contains many identical exercises to the ones included in this package, but uses 3-D visual aids such as models. **Teachers at the control schools are specifically requested not to use any MODELS when they teach this section, and to avoid using diagrams which show cells or cell organelles in a 3-D perspective.**

Please integrate the lessons contained in this package with your normal classroom teaching.

THE AIMS OF THIS PACKAGE

The aims of this package are

1. to help the pupils to become more careful and accurate observers;
2. to assist them to draw biological specimens accurately;
3. to help pupils to understand the size and scale of microscopic structures;
4. to help them to understand electron micrographs of cells and cell organelles.

HOW THE AIMS WILL BE ACHIEVED

Based on research findings about how the **teaching and learning of skills** can be achieved most effectively, the following strategies will be used.

1. A diagnostic test will be used to identify the pupils' strengths and weaknesses in drawing biological structures.
2. Pupils will be given feedback on what their strengths and weaknesses are.
3. They will then be given "remedial help" to develop their skills and abilities. Teaching methods to be used will include:-
 - a) making the pupils conscious of the fact that certain vital skills are to be developed.
 - b) motivating and encouraging them to develop these vital skills.
 - c) providing hands-on activities and exercises so that the pupils can practise and develop the skills they are taught.
4. Post-tests will be used to see how well the pupils have mastered the skills.

Above all, ENSURE THAT LEARNING BIOLOGY IS FUN. Biology - the study of life - is so exciting. Don't let boring teaching methods extinguish the pupils' desire to discover, so that learning becomes a chore.

THE IMPORTANCE OF BEING PREPARED

Research has shown the importance of the teacher in the success of any teaching "package".

Firstly, teachers need to be aware of what their own teaching goals are, in terms of knowledge, skills and attitudes to be developed in the pupils. It is hoped that the goal of this package - the development of certain skills deemed essential if biology pupils are to learn effectively - will be compatible with the teacher's own goals.

Educational research has shown that teachers should know that the successful use of curriculum materials requires the involvement of teachers and pupils, as described below.

On the part of the teacher

1. Thorough preparation including
 - * knowledge of the goals and content of each lesson;
 - * prior organization of equipment needed;
 - * arranging materials, A-V aids, etc. to be available at the right time and place.
2. A willingness to modify and improvise where necessary.
3. The ability to keep track of the progress of individual pupils, and to help each child overcome any problems (s)he might have.
4. The development of an atmosphere of excitement, challenge and love of learning.

Teachers involved in the two pilot studies for this research found that the lesson always went better when it was being taught for the second time, because they were better prepared.

On the part of the pupils

1. The ability to follow instructions.
2. The ability to co-operate in a group.
3. Socially responsible behaviour in class and with homework.
4. The ability to take responsibility for their own learning.

Many pupils may not have been taught the social and learning skills they will need in the biology classroom, skills such as

- * working co-operatively in groups
- * following instructions implicitly
- * having effective group discussions
- * making accurate observations and drawings.

It is up to the teacher to TEACH these skills and to provide the opportunity for pupils to practise and develop them.

You are earnestly requested to make the pupils aware of taking responsibility for their own learning. You are asked to see that the pupils take the exercises and activities seriously, and that they complete any exercises that they are given for homework.

The answers to these exercises should be checked with the pupils, either verbally during the next lesson, or by means of model answers pinned on a notice board, and drawn to their attention. **It is vitally important that all work is consolidated (reinforced) in some way.**

SCHEDULE OF LESSONS

This recommended "time planner" has been included so that you have some idea of how much time you will need for each of the lessons.

One of the aims of this package is to ensure that teachers do not have to deviate more than is necessary from their normal Std 8 lessons on the structure and function of cells. However, teachers are asked to include the following introductory exercises when they teach the section on the cell. **Please emphasis strongly (to the pupils) that this is NOT extra work irrelevant to the syllabus.** These lessons are to assist them to develop skills which are absolutely essential for them to succeed as biology scholars.

Thereafter the teaching is left to the teacher. However, teachers are asked to incorporate the worksheets on cell organelles, and other relevant exercises, into those lessons in which they deal with those organelles.

As teachers will realise, the active involvement of pupils in the learning task inevitably means that more time is spent teaching that section of work. Thus some of the tasks are for pupils to complete at home. Teachers are asked to ensure that pupils do complete these exercises, and that they have some sort of follow up in class, even if it is merely a class display of drawings which have been done.

LESSON 1:

- * The importance of the skills of drawing and observing in biology.
- * Diagnostic exercises on drawing and observing.

LESSON 2:

- * Developing observation and drawing skills.

LESSON 3:

- * The concept of biological sections.
- * Drawing exercise.

LESSON 4:

- * Revising the cell concept.
- * Teaching about size.

LESSON 5:

- * Revision of the basic structure of the cell (emphasising accurate drawing).
- * Sizes of cell organelles.

FURTHER LESSONS:

A series of exercises on the structure and function of organelles has been provided for inclusion in the teacher's lessons.

EVALUATING THE PACKAGE

I would greatly appreciate it if you would take the time to comment on the suggestions made in this package, and on how the pupils responded to the lessons. Your comments will be used to improve the package for possible use, at a later date, in South African classrooms.

You are asked to comment in two ways:

1. Please complete the pink form which you will find at the end of the materials for each lesson. This will provide me with information about HOW the various tasks were approached and checked, and it will also alert me to any problems which might require attention.
2. Please use a red pen to write comments directly onto the pages in this teacher's file. Copies of all the pupils' exercises have been included for this purpose. These files will be returned to me, and I will give you a replacement copy once I have made any modifications. Please indicate mistakes, inconsistencies, unclear explanations, unclear diagrams or illegible print, requests for more details, and any suggestions you have for improving the package and making it more helpful to Std 8 biology teachers.

Your assistance in testing the ideas and materials in this package, and in taking the time to comment on them, is greatly appreciated.

LESSON 1

(The importance of accurate observation and drawing)

Recommended time

One single period (30-40 minutes).

Purpose of the lesson

1. To emphasise the importance of accurate observation and drawing in biology.
2. To ascertain the pupils' ability to observe and draw accurately.

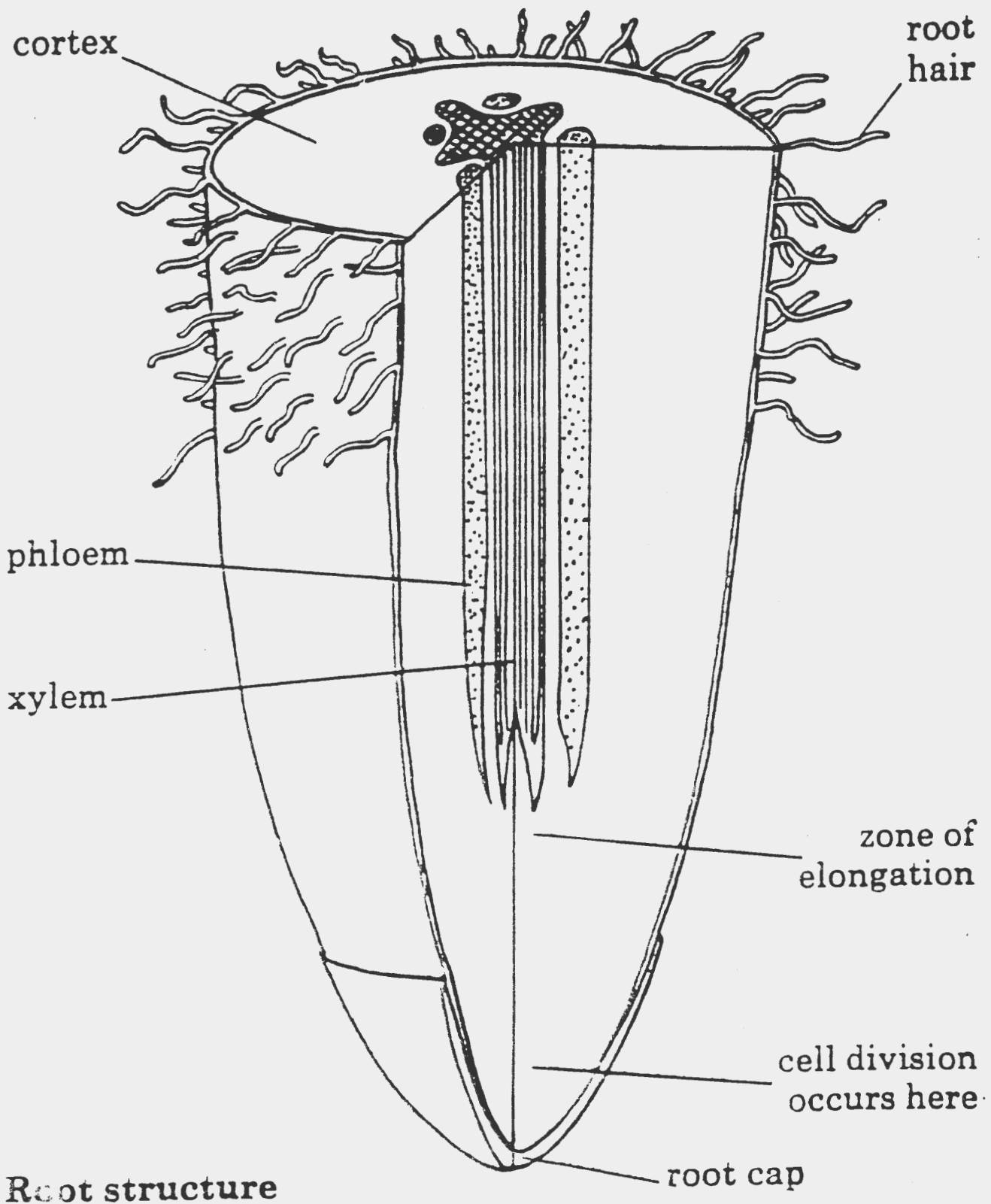
Requirements for lesson

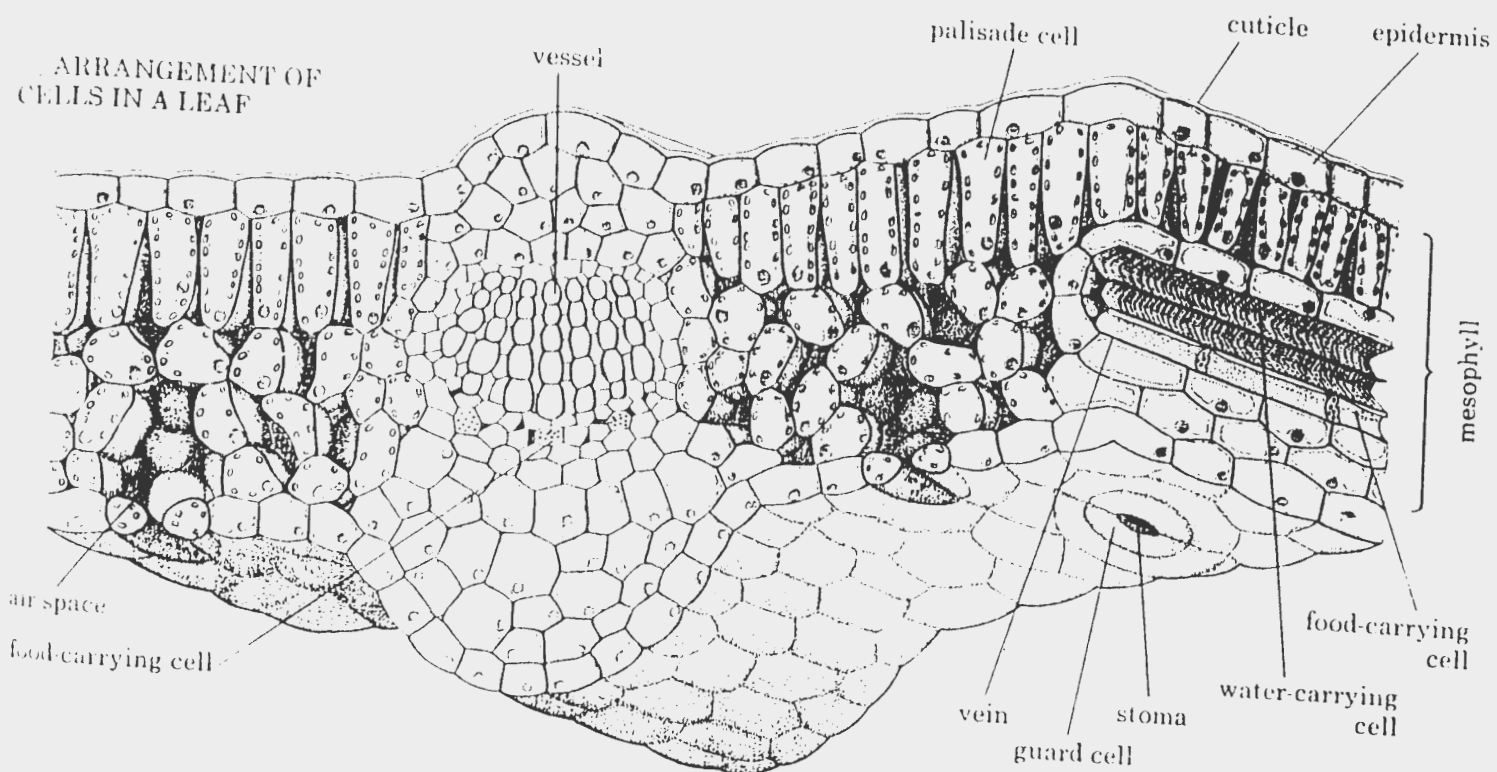
1. Suitable, large biological specimens or models to be drawn (e.g. a model of an insect, a large crab, etc.). Use one specimen or model between 4 pupils.
2. Overhead transparencies:
 - leaf
 - anther
 - root

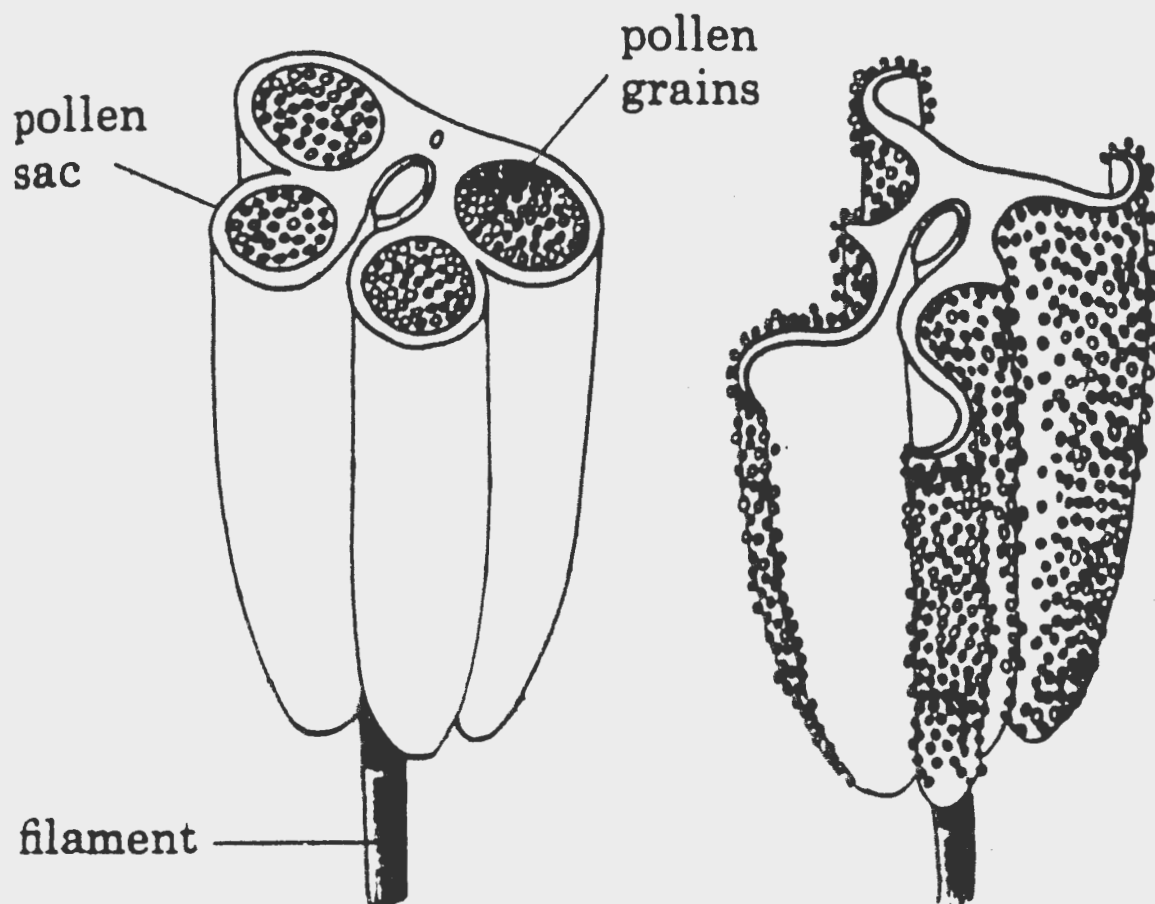
Points to be made to the pupils during the lesson

1. Start the lesson by pointing out that one of the most important ways for biologists to record information about biological specimens is to draw what they see.
2. Because biology is a science, it is vital that an **ACCURATE** record is made of biological findings, so that others may learn from the biologists' work. (Try to elicit the importance of accuracy from the pupils by discussion).
3. Emphasise that in Std 8 - 10 Biology pupils will be expected to do a lot of drawing, and they they need to develop and practise this skill. Tell them that the next few weeks will be used to teach and develop this skill.
4. Explain that it is important to know what their **PRESENT** drawing skills are like.
 - * Divide the class into small groups (about 4 pupils).
 - * Provide each group with a large biological specimen for them to draw.

- * Seat the pupils at a bench so that they can all draw the specimen from more-or-less the same angle.
 - * Allow about 10 minutes for the pupils to make a drawing of the specimen / model provided. Tell them that they should try to make it look as much like the original as possible, but they must finish in the time allowed.
5. Once this activity is completed, use the remainder of the lesson to allow pupils to look at each others' diagrams, and to say which ones they think are "best".
 6. Conduct a short class discussion to try to elicit from the pupils WHY they think those drawings are "good". i.e. what makes them good representations of the original specimen. If there is no time for this, encourage the pupils to discuss this among themselves before the next lesson.







Pollen sacs split
exposing pollen

Structure of an anther (top cut off)

Teacher's comments on lesson

School: _____ Teacher: _____ Lesson No. _____

Time spent on lesson: _____

How lesson was taught: Please mention briefly how the lesson was dealt with e.g. teacher demonstration, whole class exercise, small group work, individual pupil work etc.

When exercises were done: Please mention (for each exercise) if these were done in class, or for homework.

Checking of answers: Please indicate whether the pupils' answers were checked, and if so, how this was done (e.g. answers displayed on a board, and pupils given 5 minutes at start of lesson to check their homework, or teacher went over answers in class at the end of the lesson etc.)

COMMENTS

Problems experienced by teacher:

Problems experienced by the pupils:

General comments on the lesson:

LESSON 2

(The skill of drawing)

Recommended time

A single lesson (although a double lesson could be used at schools where a lot of importance is attached to drawing, and rules for drawing).

Purpose of the lesson

To show the pupils how they can improve their drawing skills.

Requirements for lesson

1. Overhead transparency of the Blue-breasted Schlemptygump.
2. The same models and museum specimens used for Lesson 1.

Points to make in the lesson

1. Explain to the pupils that the purpose of this lesson is to help them to draw better.
2. Use the Blue-Breasted Schlemptygump exercise to develop the skill of accurate observation and drawing (see "teacher's notes").
3. Now allow the pupils another 10 minutes to redraw the specimen they drew yesterday. Select the work of the pupils who have made the best improvement, and use it to put up a "before and after" display in the lab.
4. Finish off the lesson by going over the schools "rules for drawing" (see sample sheet attached), or provide the pupils with a set of rules to go over at home.
5. During the next few weeks, ask the pupils the sorts of questions suggested in the teacher's notes, to get them to be more observant about the world around them.

TEACHER'S NOTES

(Lesson 2)

Blue-breasted Schlemptygump drawing exercise

- Step 1: Tell the pupils that you are going to show them a picture for 20 seconds, after which they will be asked to do a drawing which looks AS MUCH LIKE THE ORIGINAL AS POSSIBLE. Whilst they are looking at the drawing they must not have their pencils in their hands - they must just look very carefully.*
- Step 2: Show them the overhead transparency of the Blue-breasted Schlemptygump for a period of 20 seconds.*
- Step 3: Switch off the overhead projector, and allow the pupils to do the drawing.*
- Step 4: When they have finished, allow the pupils to look at the OHT again. Ask them to use a different colour pen or pencil to alter their drawing so that it looks more like the original.*
- Step 5: Elicit from the pupils what points they think are important if one wants a drawing to look as much like the original as possible. They should be able to tell you the importance of the following points. As a pupil mentions each one list it on the chalk-board, and show examples on the Blue-breasted Schlemptygump OHT which illustrate the point.*

SHAPE: Point out the angular shape of the jaw, the bulbous shape of the nose, the squared edges of the "feathers" on the head. If these are not depicted accurately the whole drawing looks wrong.

RELATIVE SIZE: Point out that the head is at least half as big as the body, and the body is about twice as long as it is high. If relative sizes are wrong, the picture does not look right.

POSITION OF STRUCTURES: Point out the position of the tail halfway down the back, the spacing of the "feathers" on the top and back of the head, and the position of the feet relative to the breast. If these are not in the correct place, the drawing will not look like the original.

NUMBER OF STRUCTURES: Point out the number of toes on front and back legs, the number of "feathers" etc. Mention that in biology, a specific number of some feature is often a species-specific characteristic - e.g. *Pinus sylvestris* has just two needles per dwarf shoot, and if they draw a specimen of this species of pine with fewer or more needles (because they haven't looked carefully) their drawings will be scientifically inaccurate.

- Step 6: Relate the importance of each of these points to making accurate drawings of anything they draw.*

NB 1: It is realised that this exercise does not only measure the pupils' ability to observe and draw accurately, but also a degree of memorisation. However, it does serve to make the pupils aware of what they need to consider in order to do an accurate drawing, and its use is therefore justified.

Developing powers of observation

Observational skills can be followed up for several lessons by asking the pupils appropriate questions which will make them more observant. For example:

- * What colour are the curtains in the school hall?*
- * How many steps are there in front of the entrance of the school?*
- * What animal is shown on the poster on the back wall? (don't let them turn round to check - the poster has been there for weeks).*

Games such as these can help the pupils to become better observers.

BLUE-BREADED SCHLEMPYGUMP

TEACHER'S NOTES

Observation skills can be followed up by asking the pupils to draw a picture of a creature which will resemble the creature in the school hall.

- When asked to draw the creature in the school hall.
- How many more are there in front of the creature in the school hall.
- What animal is the creature in the school hall.
- What animal is the creature in the school hall.

Step 1: Tell the pupils that you are going to show them a picture of a creature which they will be asked to draw when a light is shown. AS MUCH AS POSSIBLE. Why they are looking at the drawing they must not have their pencils in their hands - they must just look very carefully.

Step 2: Show them the overhead transparency of the blue-tinted Schlangengruppe for a period of 20 seconds.

Step 3: Switch off the overhead projector, and allow the pupils to do the drawing.

Step 4: When they have finished, allow the pupils to look at the OHT again. Ask them to use a different colour pen or pencil to alter their drawing so that it looks more like the original.

Step 5: Elicit from the pupils what points they think are important if one wants a drawing to look as much like the original as possible. They should be able to list the importance of the following points. As a model mentions each one list it on the chalk-board, and show examples on the blue-tinted Schlangengruppe OHT which illustrate the point.

SHAPE: Follow the irregular shape of the body, the hollow shape of the head, the shape of the "fingers" on the head. If there are not described in the drawing the whole drawing will be wrong.

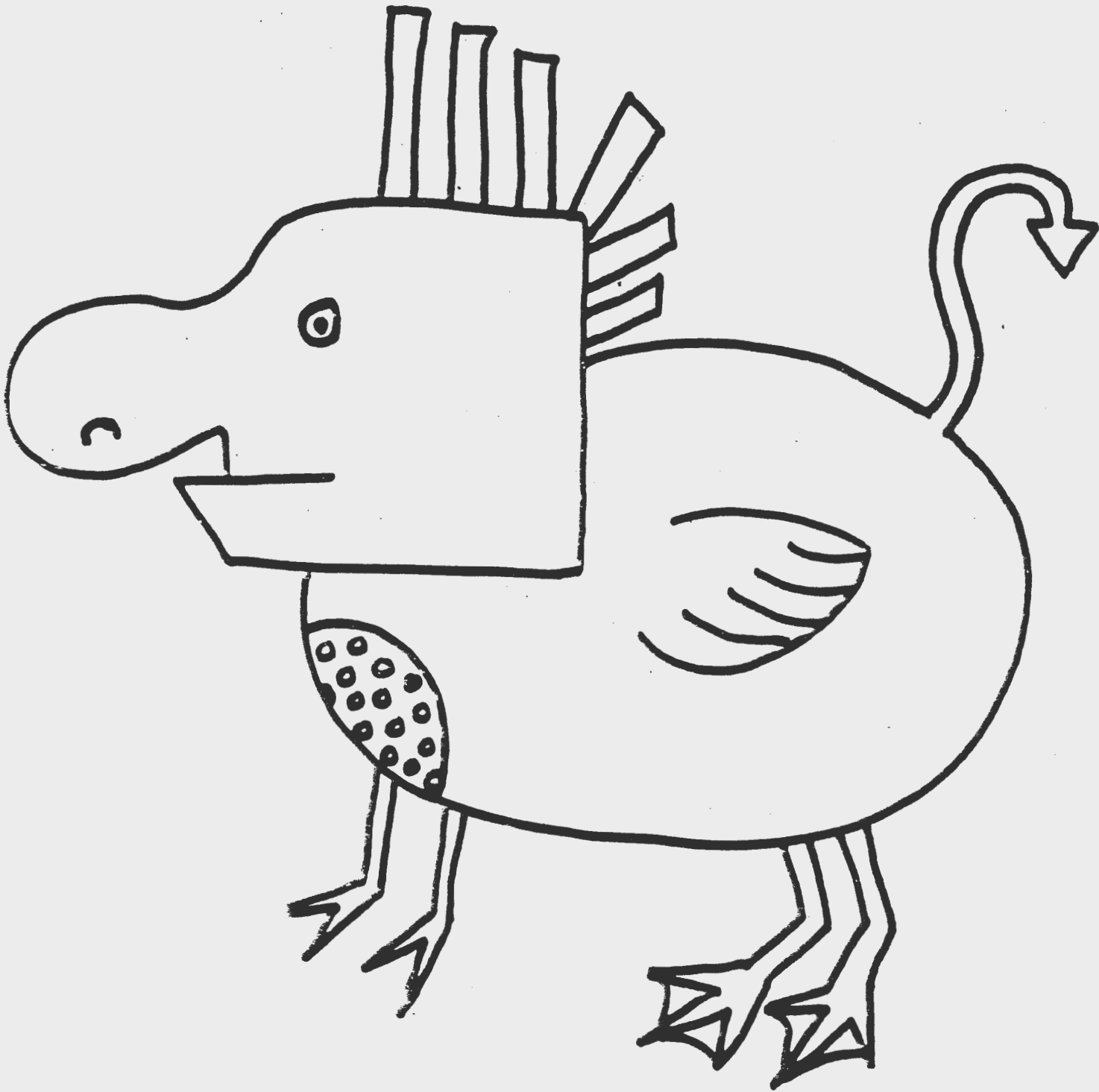
RELATIVE SIZE: Follow the head is as high as it is long, and the body is about twice as long as it is high. If relative size is not correct the picture does not look right.

POSITION OF STRUCTURES: Follow the position of the tail, the position of the head, the position of the "fingers" on the head, and the position of the feet relative to the head. If these are not in the correct place, the drawing will not look like the original.

NUMBER OF STRUCTURES: Follow the number of eyes, the number of legs, the number of "fingers" on the head. In biology a specific number of parts is often a characteristic of a species. If the number of parts is not correct the picture does not look right. If the number of parts is not correct the picture does not look right.

Step 6: Relate the importance of each of these points to making a drawing of anything they draw.

NB 1: It is realized that this exercise does not only measure the pupils' ability to observe and draw accurately, but also a degree of concentration. However, it does serve to make the pupils aware of what they need to observe in order to draw an accurate picture, and it is a valuable exercise.



BLUE-BREASTED SCHLEMPITYGUMP

Teacher's comments on lesson

School: _____ Teacher: _____ Lesson No. _____

Time spent on lesson: _____

How lesson was taught: Please mention briefly how the lesson was dealt with e.g. teacher demonstration, whole class exercise, small group work, individual pupil work etc.

When exercises were done: Please mention (for each exercise) if these were done in class, or for homework.

Checking of answers: Please indicate whether the pupils' answers were checked, and if so, how this was done (e.g. answers displayed on a board, and pupils given 5 minutes at start of lesson to check their homework, or teacher went over answers in class at the end of the lesson etc.)

COMMENTS

Problems experienced by teacher:

Problems experienced by the pupils:

General comments on the lesson:

LESSON 3

(The concept of sections)

Recommended time

A double lesson

Purpose of lesson

1. To introduce the concepts of longitudinal- and cross-cuts, and longitudinal- and cross-sections.
2. To practice the the prediction of sectional shapes of geometric structures and of living specimens.

Requirements for lesson

1. Exercises (1 per pupil)
 - * sectioning geometric shapes
 - * making cuts through biological structures
 - * banana and mushroom exercise
2. Overhead transparencies
 - * biological sections (the slice of bread analogy)
 - * length-wise and cross-cuts
 - * cutting sections of a plant stem
 - * 2 pencils
 - * 2 caterpillars
 - * root tip (from Lesson 1)
 - * geometric shapes (answers to exercise)
 - * exercise on cutting through living things
 - * mushroom sections (answers to exercise)
 - * banana sections (answers to exercise)

Points to make to the pupils

1. Explain that biologists need to be able to look at whole structures (or diagrams of whole structures) and to imagine what they would look like if they were sliced in half.

2. Use the OHT to show the directions of a lengthwise cut, and a cross-cut (the OHT uses a cone shape as an example).
3. Allow the pupils to work in pairs to complete the exercise on geometric shapes. For each diagram they should
 - * imagine what the shape would look like in 3-D,
 - * imagine cutting it through **FROM TOP TO BOTTOM**,
 - * draw what it would look like **face on** (viewed directly from the front),
 - * imagine cutting it in half **ACROSS** the shape,
 - * draw what it would look like face on.
4. Ask each pupil to work through the exercise on their own. They should then compare their drawings with those of a partner, and then **DISCUSS** any discrepancies.

NB: If you are short of time for the lesson, allow them to do the second page of the exercise for homework.

5. Explain that lengthwise and cross-cuts can also be made through **biological structures**. Demonstrate on a pupil using a ruler as a "knife".
6. Hand out the exercise on cutting through a mushroom and a banana.
 - * Allow the pupils to work in pairs or small groups so that they can discuss their ideas as they draw.
 - * Allow them 10 minutes to complete this exercise.
 - * Remember to go over the answers with them next time, or to put model answers on the noticeboard for them to check.
7. Explain the difference between **cuts** and **sections** (see "teacher's notes").
8. Use the OHT of the two pencils, and the one of the two caterpillars, to show that it is the **shape** of the structure which determines whether the cut is **lengthwise**, and not the orientation of the structure (see "teacher's notes").
9. Discuss the idea that longitudinal cuts can be made in many planes (e.g. from back-to-front or side-to-side) as long as they are lengthwise cuts. Cross-cuts can also be made in many places on the specimen or shape (see "teachers' notes").
10. Introduce the following terms:
 - **anterior** (front or head end)
 - **posterior** (back or tail end)
 - **dorsal** (top in invertebrates and most animals, but the back in man as he walks upright)
 - **ventral** (lower side in invertebrates and most animals, but the front of man, because of his posture).
11. Give the pupils the exercise on cutting sections through biological structures, to do for homework

TEACHER'S NOTES

(Lesson 3)

The difference between a "cut" and a "section"

It is important to differentiate between these two terms.

A CUT: *Whether this is a longitudinal or transverse cut, it involves only a single cut being made through the organism. Use the OHT "length-wise and cross-wise cuts" to illustrate "cuts".*

A SECTION: *This would involve two cuts being made to produce a thin slice of the specimen. Use the analogy of a slice being cut out of a loaf of bread (illustrate this with the OHT). Sections are usually turned and viewed "face-on", and this cut surface is what should be drawn.*

The question of orientation

*The question of orientation of an object and whether or not it affects where a section is cut, is an interesting one. Use the OHT of the two pencils as an example. If one is making a top-to-bottom cut, does it matter which way the pencil is lying? Point out that it would be better to use a term like "length-wise cut", as then it will not matter how the pencil is lying, because the cut will always be along the **length** of the pencil.*

*The same holds true for biological structures. Use the OHT of the two caterpillars to show that a **longitudinal section** (L.S.) will always be a LENGTH-WISE cut or NOSE-TO-TAIL in the case of an animal. They will not have a circular L.S. if the caterpillar is climbing up the wall, and a long sausage-shaped L.S. if the caterpillar is walking across the floor.*

*The most common type of L.S. that pupils are likely to encounter is the **median** L.S. made through the centre of the specimen rather than off to the side. In the case of animals the cut will be between the eyes along the line of symmetry which will divide the body into two mirror-image halves.*

*A **cross section** (X.S.) or **transverse section** (T.S.) will be cut across the body at right-angles to the longitudinal section. However, it could be cut across the body at many different levels.*

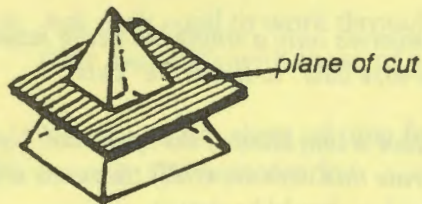
Get the pupils to tell you where a L.S. and a X.S. through a bi-ped (like a human) would be cut, as well as through a quadruped (like a dog). (Get them to demonstrate on a pupil, using a ruler as a "knife").

This becomes particularly important in the next lesson where you are dealing with sections of living things.

Where to cut the sections

CROSS-CUTS

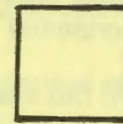
*It is important to point out that a cross-cut could be made in many different places on an object or specimen, as long as it is cut **across** the specimen. In the "sectioning geometric shapes" exercise, for example, the size of the cross-cut of the pyramid will depend on how close to the top of the pyramid the cut is made*



Cut surface viewed "face on"



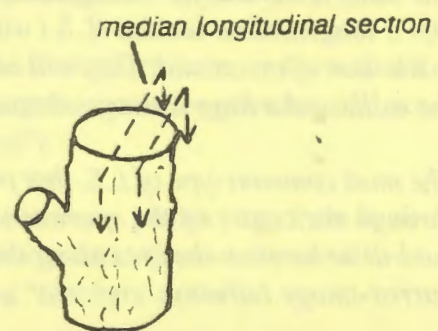
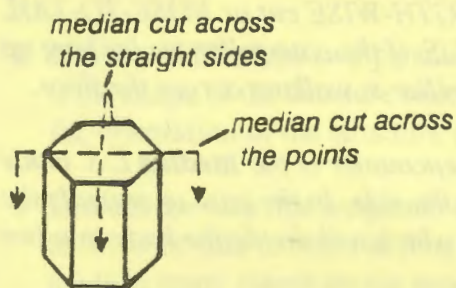
higher cut



lower cut

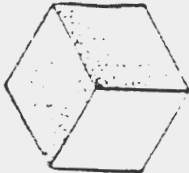




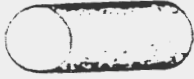
LONGITUDINAL CUTS

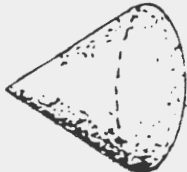

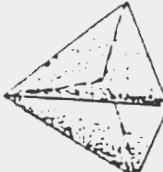
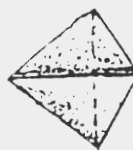


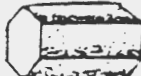
*In the case of longitudinal cuts, a similar statement can be made. There are many planes in which a longitudinal cut can be made, as long as it is "top-to-bottom" or "nose-to-tail". In biology the type of longitudinal section the pupils are likely to encounter is the **MEDIAN LONGITUDINAL SECTION** - made through the centre of the specimen rather than off to the side.*



Sectioning geometric shapes

- 1. Try to imagine the geometric shape shown in each diagram as it would look in 3-D
- 2. Imagine slicing it in half "LENGTH-WISE", and viewing the cut half "face-on". Draw, in the first column, what you think it would look like.
- 3. Now imagine cutting a "CROSS-CUT" through the 3-D shape, and viewing it "face-on". Draw what you think it would look like, in the second column.

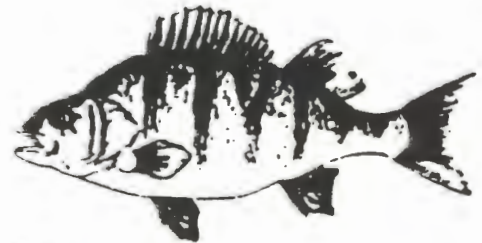
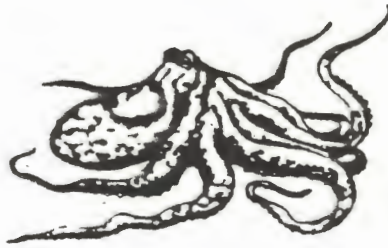
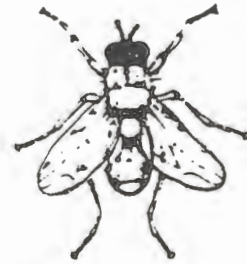
3-D shape	length-wise cut	CROSS-cut
		
		
		
		
		
		

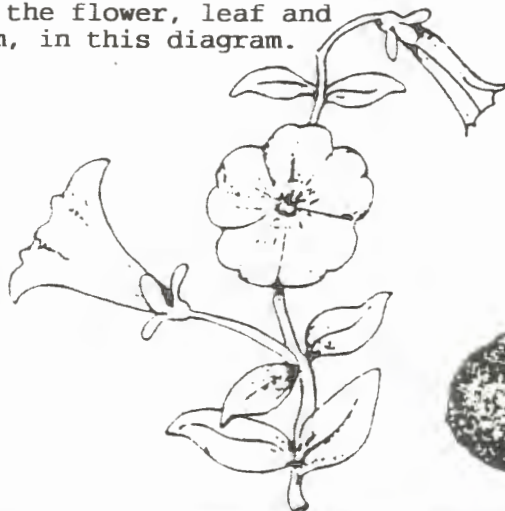
MAKING LONGITUDINAL-CUTS AND CROSS-CUTS THROUGH BIOLOGICAL STRUCTURES

1. By drawing a solid line, indicate where you would cut through each of the biological structures shown below, if you wanted to make a LONGITUDINAL CUT (or a LONGITUDINAL-SECTION).
2. Then, by drawing a dotted line, show where you would cut through each structure if you wanted to make a CROSS-CUT (or a CROSS-SECTION).

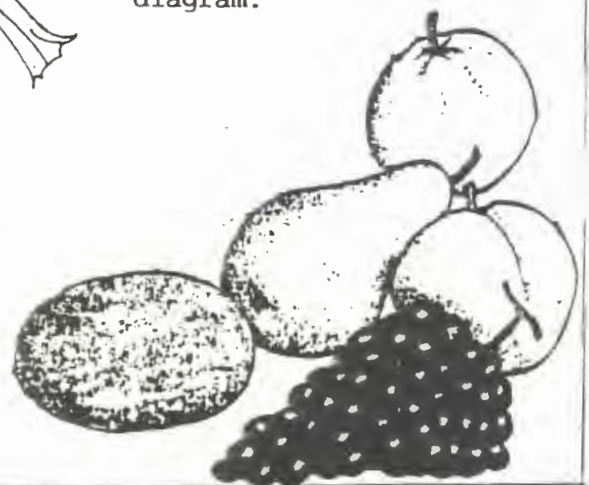
NB: Some of them are sneaky, so you will have to think!



Indicate the L.S. and X.S.
for the flower, leaf and
stem, in this diagram.



Indicate the L.S. and X.S.
for the pear only, in this
diagram.



Sectioning biological structures

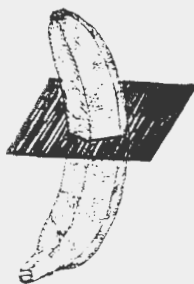
The purpose of this exercise is to see how well you can use the information given to you in some stereograms (3-D pictures). This information must be used to predict and draw how two common objects (a banana and a mushroom) will look if they are cut longitudinally (from top to bottom) and across (from side to side). All drawings should be done as if the cut object was turned so that you were facing the cut surface face-on.

Look carefully at the depth cues in the diagrams. Also try to remember what you have learned about the structure of bananas and mushrooms from eating them.

EXERCISE 1:

Carefully examine the stereogram of a whole banana.

- 1a) Try and imagine how it would look if cut across, as in the small sketch, and viewed face-on. DRAW YOUR ANSWER.



- 1b) Then imagine what it would look like if it was cut length-wise (in the plane of the page). DRAW how it would appear face-on.

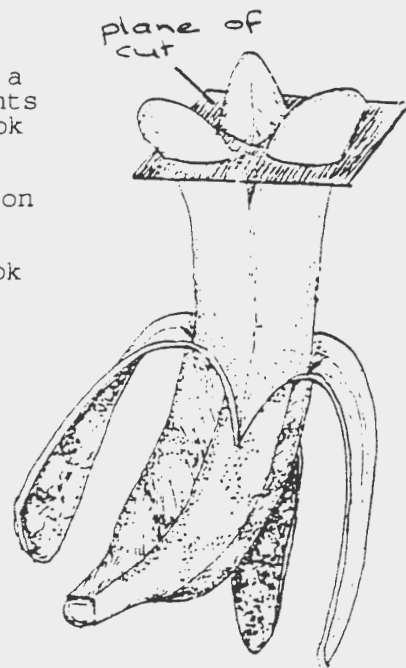


EXERCISE 2:

Have you ever put your finger down the centre of a banana to divide it into its three natural segments (as shown here)? Try to imagine what it would look like if you did this.

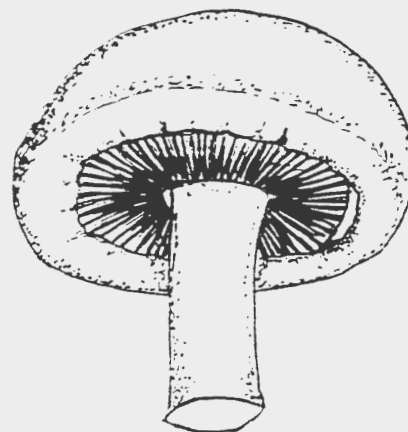
Now imagine cutting the banana ACROSS in the region indicated in the diagram.

Draw what you think the cut surface would look like, face-on.

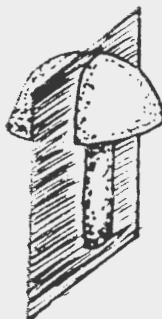
**EXERCISE 3:**

Carefully examine the stereogram (3-D diagram) of the mushroom (shown on the right).

- 2a) What would it look like if cut across in the three planes shown in the small sketches (below).
Draw your predictions.



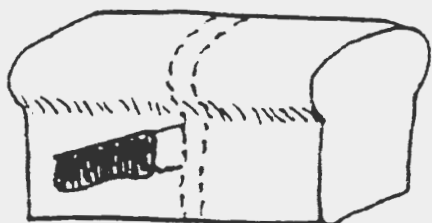
- 2b) Now draw what you think it would look like if cut length-wise, as shown in this sketch.



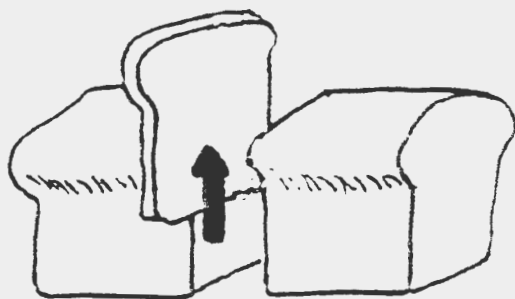
Biological sections (a comparison)

Cutting a slice of bread

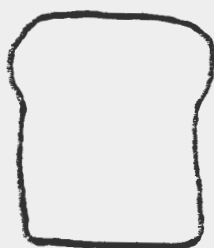
Cutting a slice



Removing slice

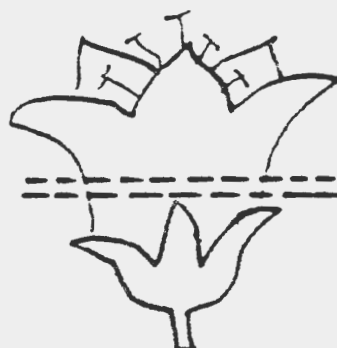


Slice turned & viewed face-on

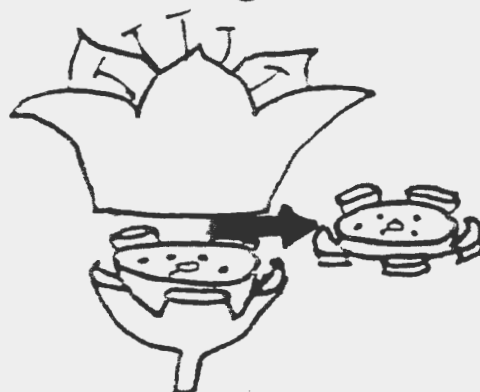


Cutting a biological section

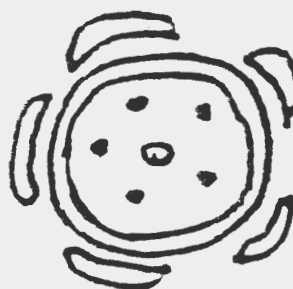
Cutting a section



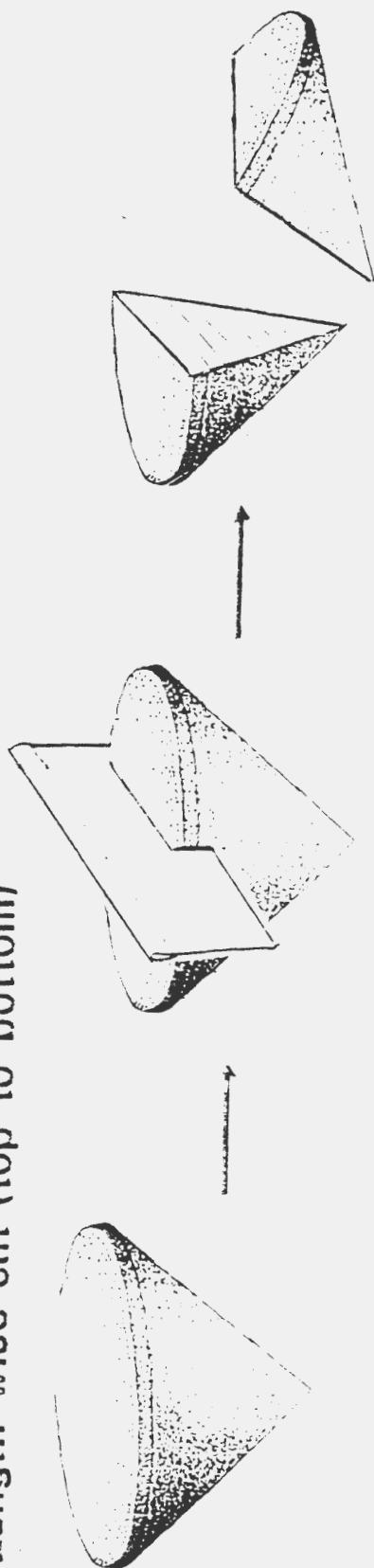
Removing section



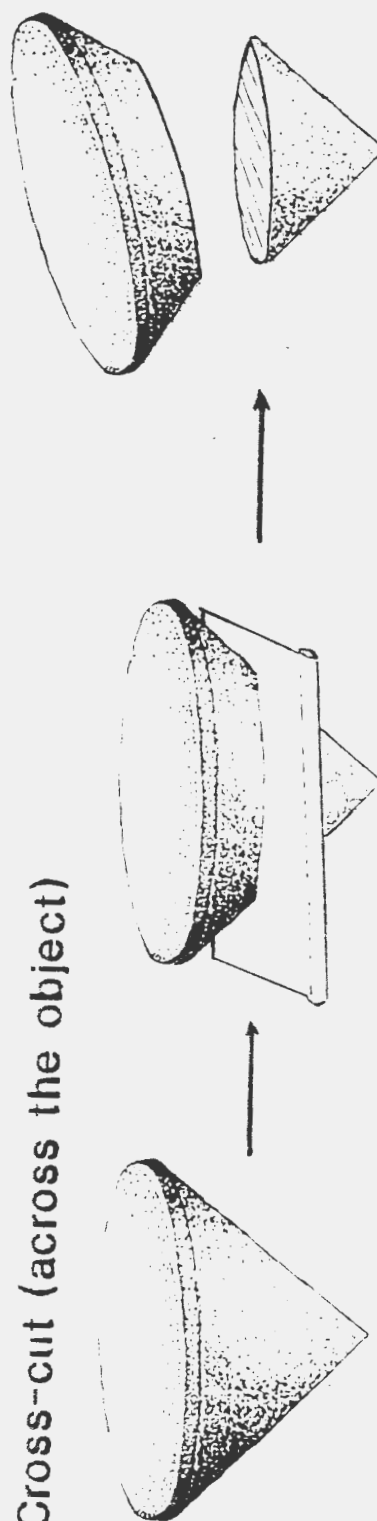
Section turned & viewed face-on

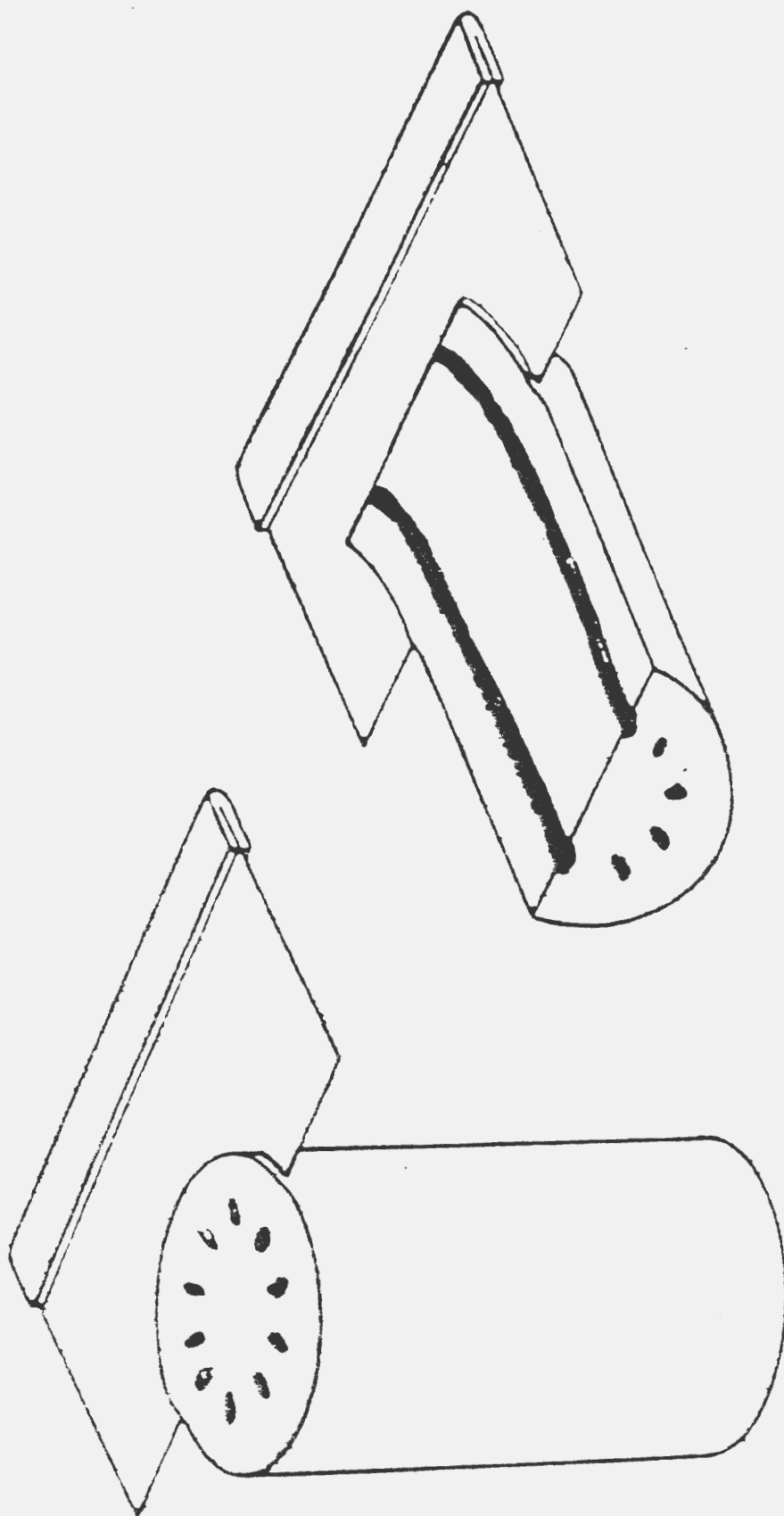


Length-wise cut (top-to-bottom)



Cross-cut (across the object)

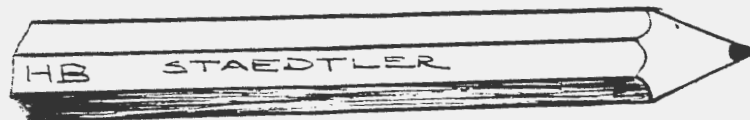
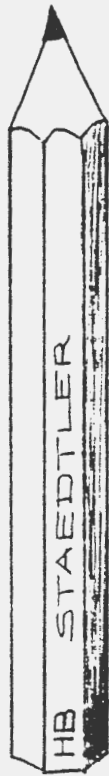




longitudinal
section

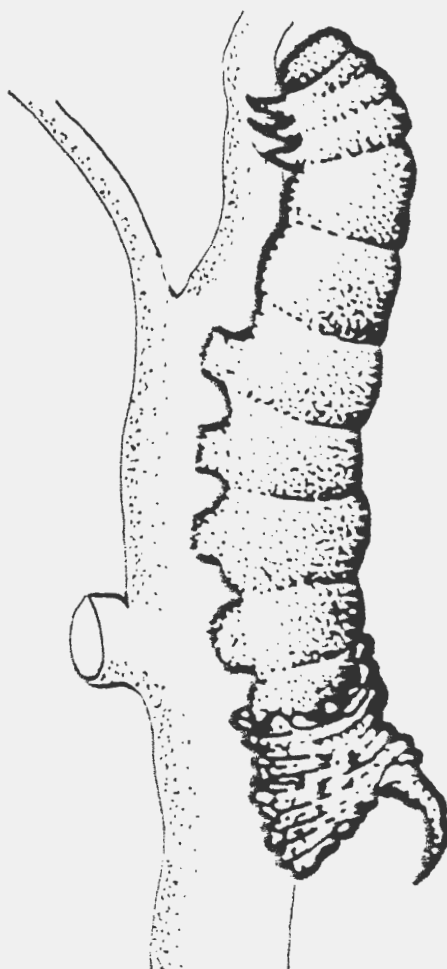
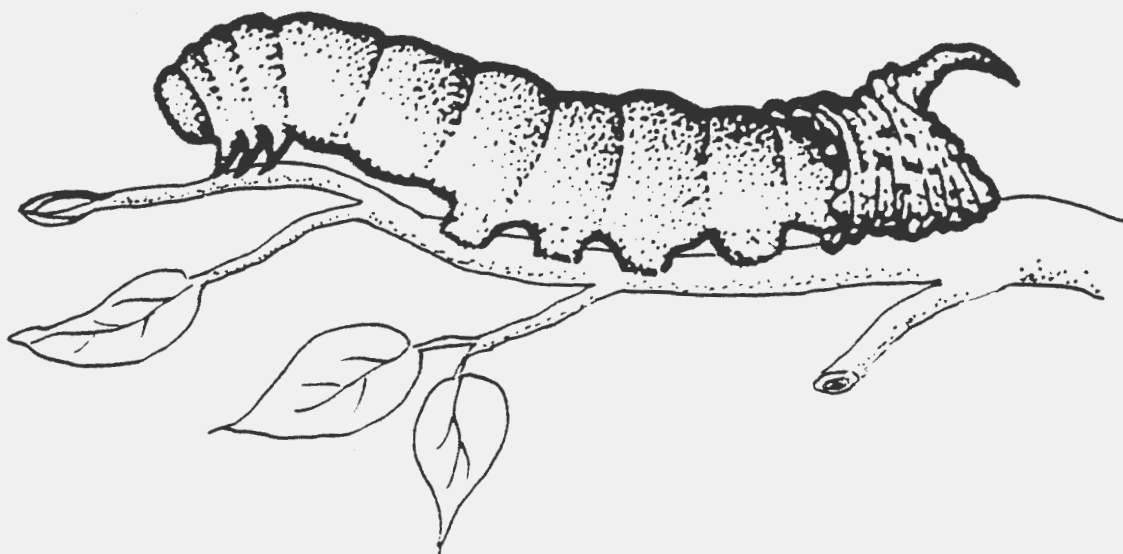
transverse
section

Cutting sections of a plant stem

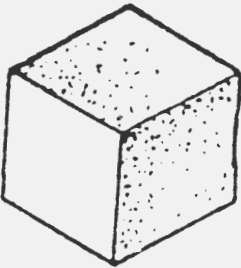
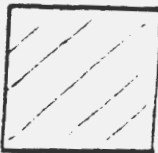
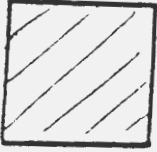
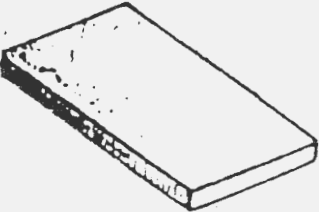





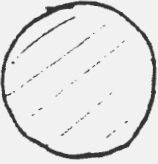
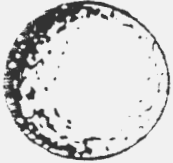
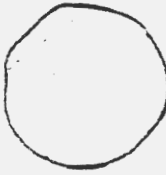
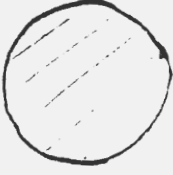
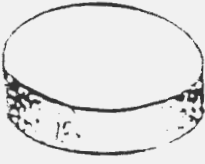







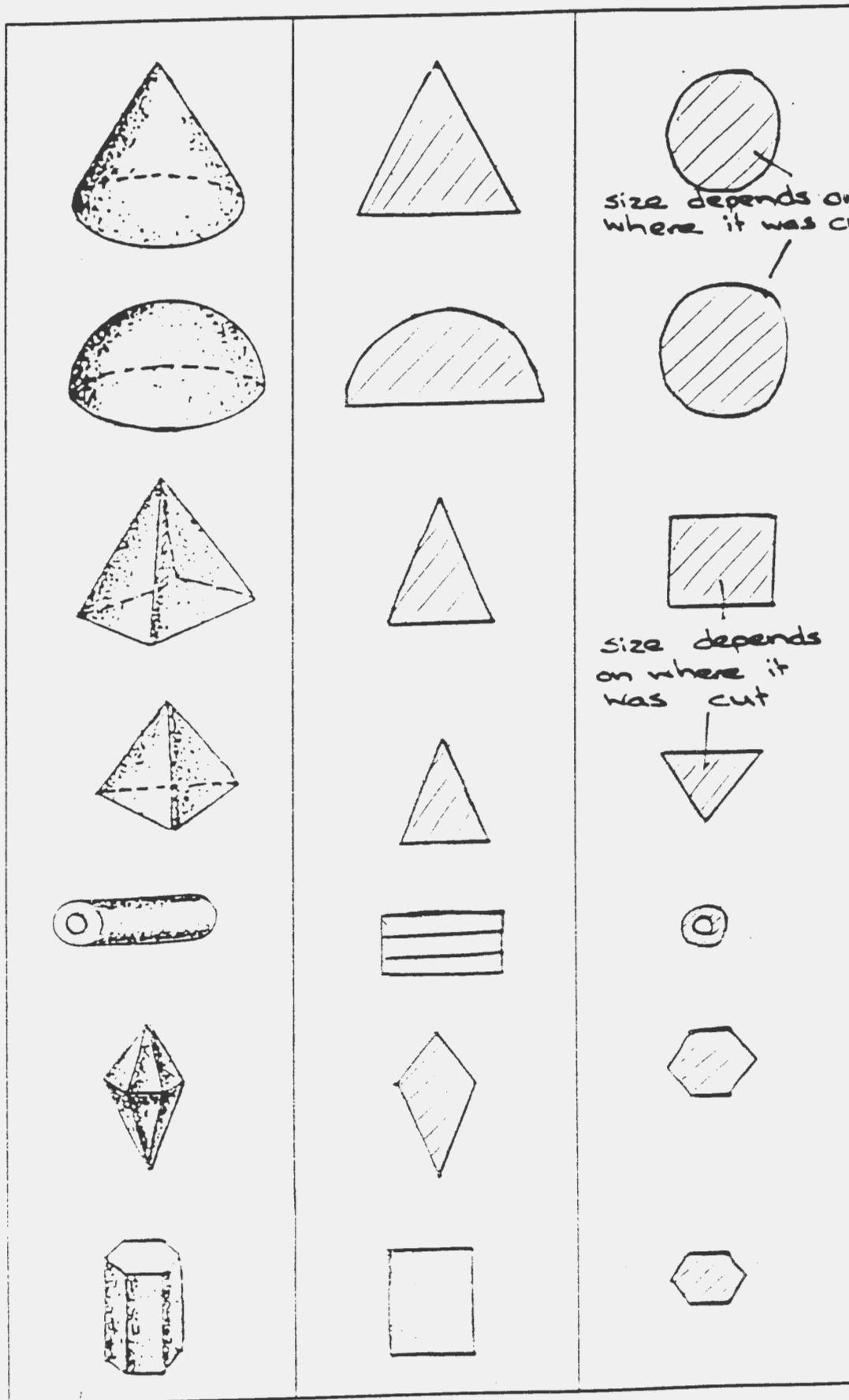
DOES ORIENTATION MATTER?

1. What will a length-wise cut (from top-to-bottom) look like for each of the pencils?
2. What will a cross-cut look like for each of the pencils?

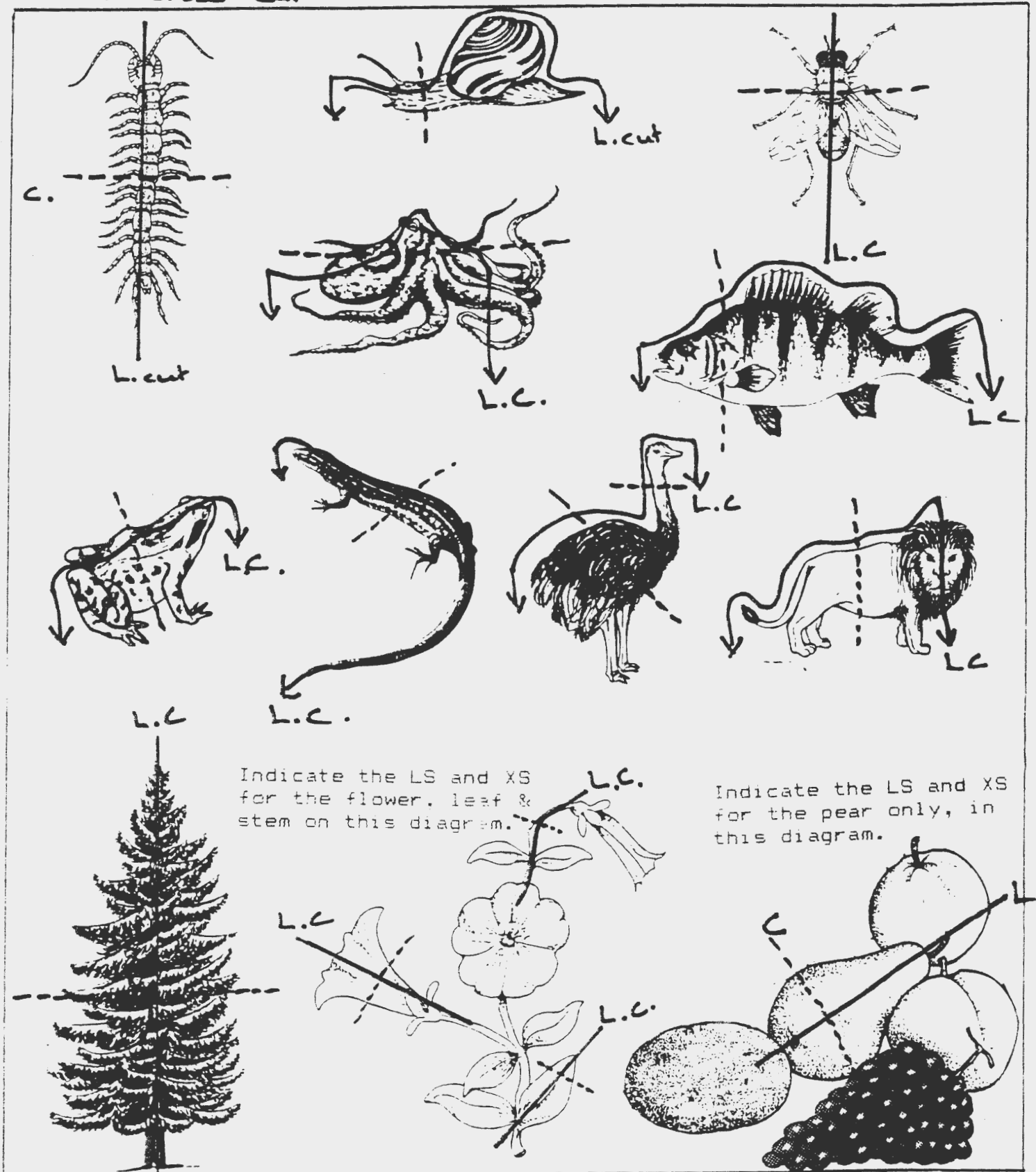


Sectioning geometric shapes

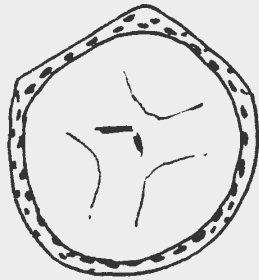
3-D shape	length-wise cut	cross-cut
	<p>Take careful note of shapes and sizes</p> 	
	 <p>or</p> 	
		
		
	<p>This could be the other way around. It depends on your interpretation of <u>lengthwise</u></p> 	
		



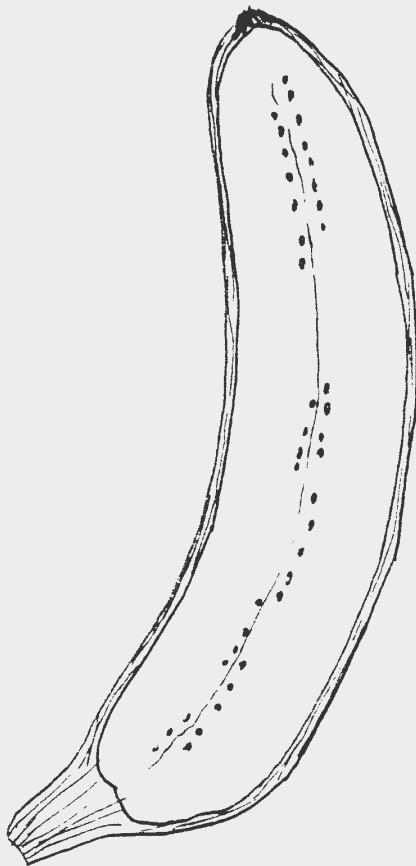
— = longitudinal cut
 --- = cross cut.



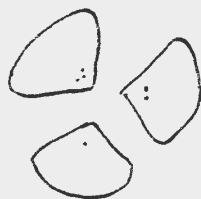
Banana



Cross-cut

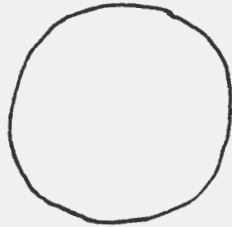


Longitudinal cut



Cross-cut of
split banana

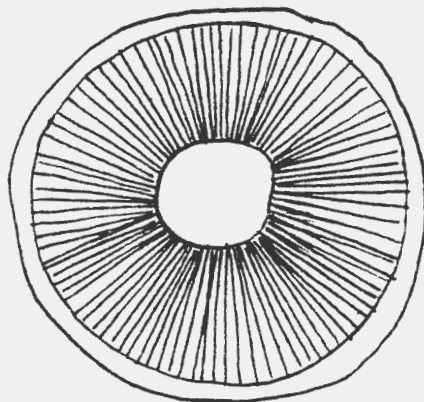
Mushroom



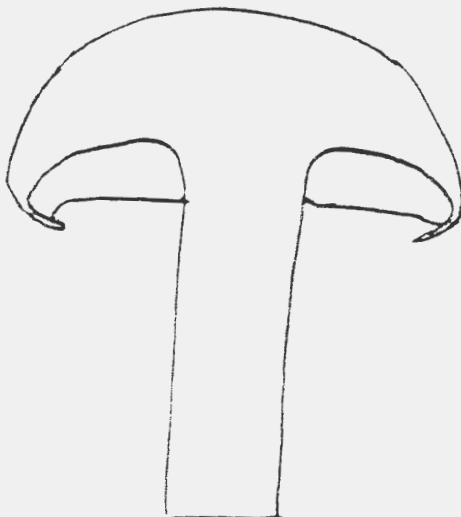
Cross-cut 1



Cross-cut 2



Cross-cut 3



Longitudinal cut

Teacher's comments on lesson

School: _____ Teacher: _____ Lesson No. _____

Time spent on lesson: _____

How lesson was taught: Please mention briefly how the lesson was dealt with e.g. teacher demonstration, whole class exercise, small group work, individual pupil work etc.

When exercises were done: Please mention (for each exercise) if these were done in class, or for homework.

Checking of answers: Please indicate whether the pupils' answers were checked, and if so, how this was done (e.g. answers displayed on a board, and pupils given 5 minutes at start of lesson to check their homework, or teacher went over answers in class at the end of the lesson etc.)

COMMENTS

Problems experienced by teacher:

Problems experienced by the pupils:

General comments on the lesson:

LESSON 4

(Revision of the cell concept, and looking at size)

Recommended time

A single lesson

Purpose of lesson

1. To emphasise that living organisms are made up of SYSTEMS, each adapted for a specific function.
2. To explain that all systems are made of building blocks called cells.
3. To emphasise that while all cells have a certain basic structure, they are structurally modified to perform particular functions.
4. To teach the units of measurement for cells (micrometers), and to give the pupils exercises to help them visualise the size of cells.

Requirements for lesson

1. Overhead transparencies
 - concrete frame of building
 - comparison of building and vertebrate
 - different animal cells (with sizes)
 - pin-head and animal cells
 - animal-cells showing structural adaptations
2. Handouts (1 per pupil): Exercise on size
3. Box of pins (1 per pupil)
4. Answer sheets (exercise on size)

Points to make to the pupils

1. Ensure that the answers to the exercises done in the previous lesson are checked.
2. Using the model of a large department store, and a question-and-answer strategy, develop the concept of the building being made up of several systems, each to perform a particular FUNCTION (see "teachers' notes"). NB: Use the OHT of the concrete framework to get the discussion going.
3. Develop the analogy of living organisms (e.g. a plant or the human body) having systems to perform particular functions. (Use the OHT provided to summarise the comparison).

4. Develop the idea of using "building blocks" to build a department store. Emphasise that the building materials differ depending on the function they have to perform (see "teachers' notes").
5. Revise the idea of cells as the building blocks of living things. However, point out that not all cells have the same basic structure (which they learned about in Std 7). Cells are adapted so that they are structurally suited to do the job they have to do (show both OHTs of cell types).
6. Explain that many pupils struggle to understand the size of cells, and the organelles inside them. They often get confused by the nucleus of an atom (in science) and the nucleus of the cell.
7. Use the rest of the lesson to help the pupils develop an understanding of size, and how atoms relate to cells.
8. Explain that the unit used to measure the cell is the micrometer (μm).
 $1\text{mm} = 1000\mu\text{m}$.
9. If a pinhead is 1mm across, that will be $1000\mu\text{m}$. Use the OHT provided, and elicit from the pupils the answers to the questions on it.
10. Let pupils do the exercise on cell size, if there is time. If not, give it to them for homework. (Don't forget to follow up to see that they can all do the calculations).

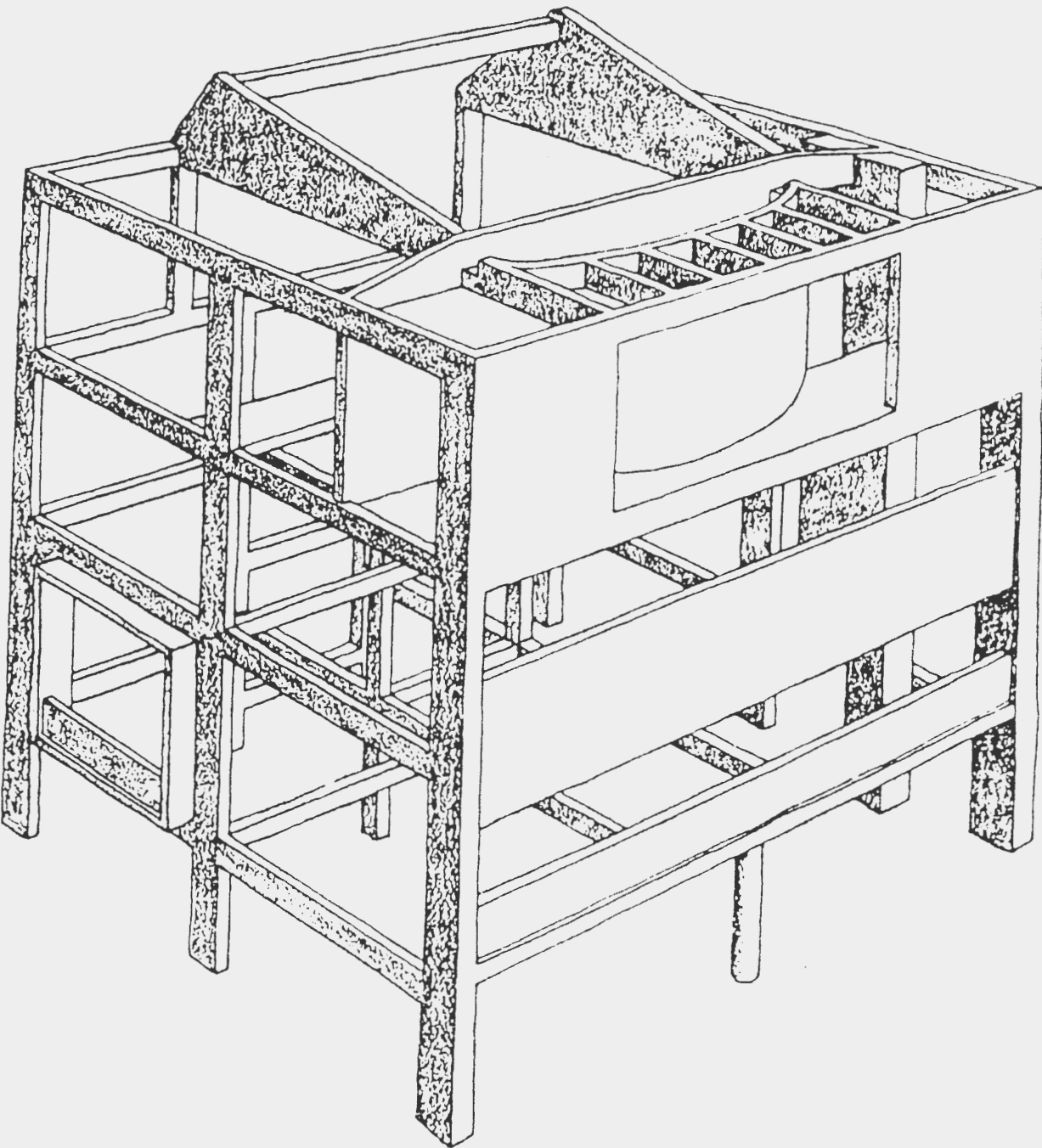
TEACHER'S NOTES (Lesson 4)

The building analogy

1. Ask the pupils if they have watched a large building being erected. What gets built first? Use the OHT of the concrete frame-work to elicit the idea of a strong **support** system.
2. Ask how everything inside the building will be **protected**, and elicit from the pupils the use of walls, windows, roofs etc.
3. How will people who use the building, as well as the necessities they require for the activities in the building, be **transported** to where they are needed? Elicit that lifts, stairs, escalators, passages, pipes, air conduits, electrical wiring etc. are used to transport them. Discuss examples of transport of people, water, electricity, fresh air, etc.
4. How will **waste-matter be removed**? Elicit that drains, sewers, refuse removal by cleaners etc. will be used.
5. How will **energy be supplied**? Discuss electricity (for heat, light etc.) or coal for the boiler system.
6. How will people in different parts of the building **communicate**? They could use telephones or an inter-com system.
7. Develop the idea of using particular **SYSTEMS** to perform particular functions.
8. Develop the idea that in living organisms (e.g. plants and animals) a similar set-up exists. Certain jobs have to be done (all of those highlighted in the "building" analogy used above, for example). Each of these tasks will be performed by a certain system in living organisms.
9. Use the OHT to develop the comparison using **FUNCTION** as the basis for the comparison of systems.

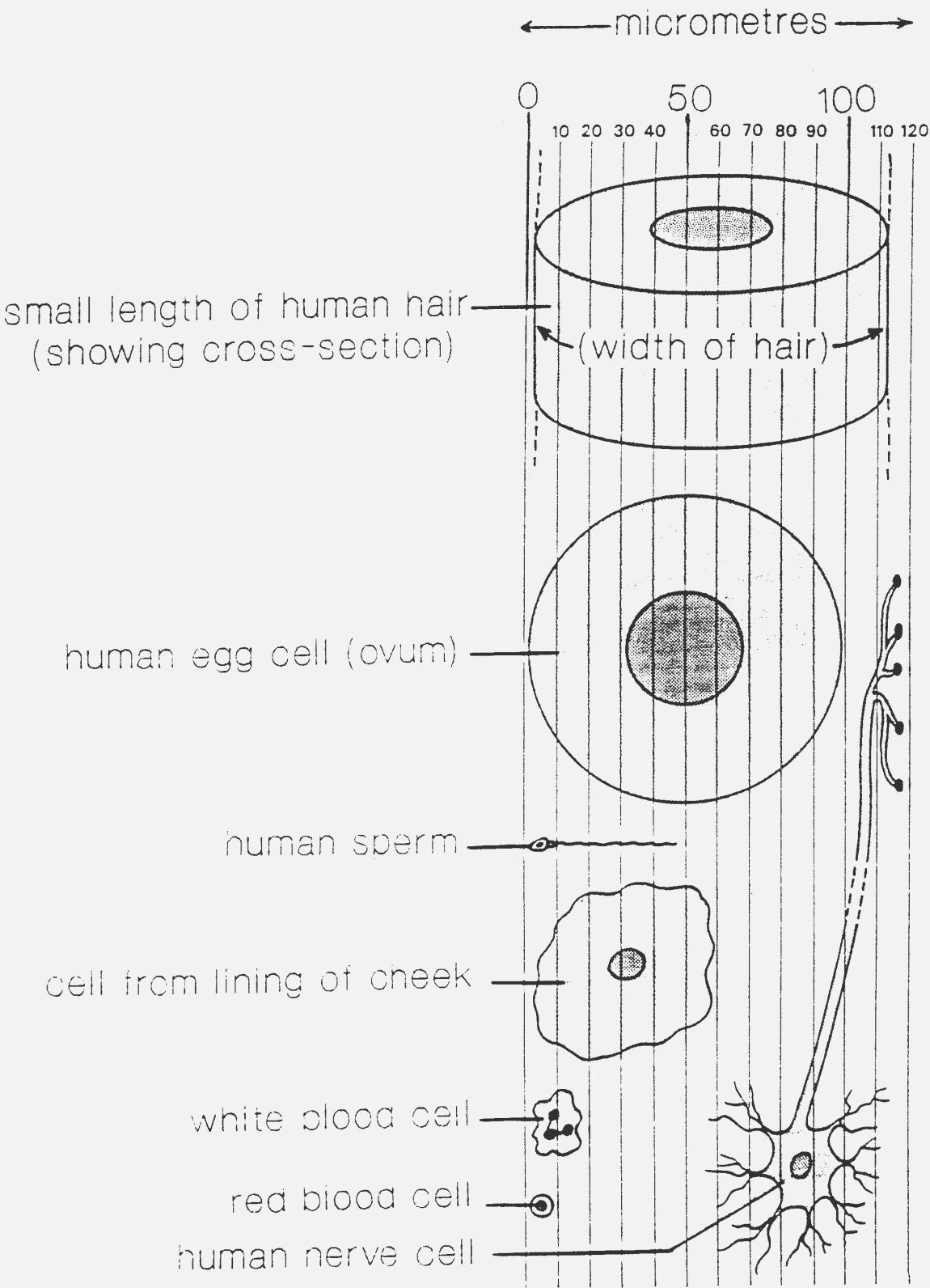
Building blocks

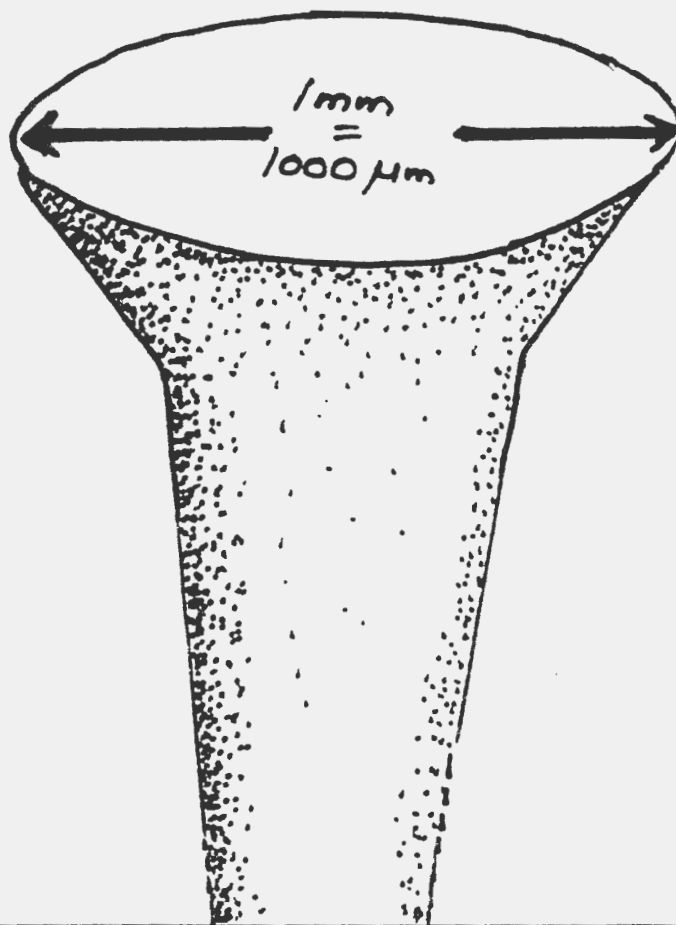
1. In the building, a variety of building materials are used to make the necessary systems.
2. Start with the idea of bricks as the building units (blocks) of walls. Point out that bricks, however, would be inappropriate for making drainpipes or windows. So building blocks (units) need to be structurally adapted so that they will perform the job for which they are required (e.g. sheets of glass for windows, so that they will let in the light, as well as protect the inside of the building).
3. The same is true of plants and animals. All systems are made up of building blocks, which have the same basic components learned about in Std 7. But all cells will be structurally adapted so that they can perform the jobs they have to do.
4. Show the OHT of different cell types, to give an idea of the ranges of shapes and sizes.



Function	Building	Animal (vertebrate)
strength/support	concrete framework	skeleton
protection	walls & roof (brick, glass, wood, tiles)	skin, hair, nails
transport	lift, stairs, pipes passages	respiratory and blood systems
raw materials in	deliveries, water electricity	digestive system respiratory system
waste products out	rubbish removal, & sewerage system	excretory system (bowels/kidnies)
message system	telephone, intercom,	nervous system
energy production	heating system, lights	respiratory system

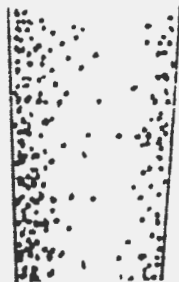
A comparison of the size of human cells to the thickness of a human hair

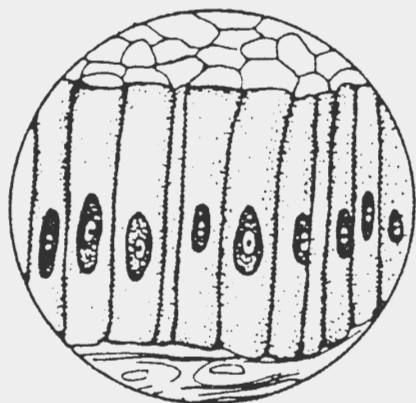




How many cells would fit next to each other across the diameter of a pin-head?

1. single-celled bacteria $1\text{ }\mu\text{m}$ long?
2. red blood cells?
3. white blood cells?
4. cells from the lining of the cheek?
5. human sperm cells (head to tail)?
6. human egg cells?

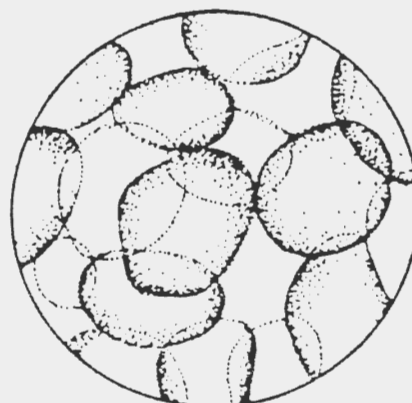




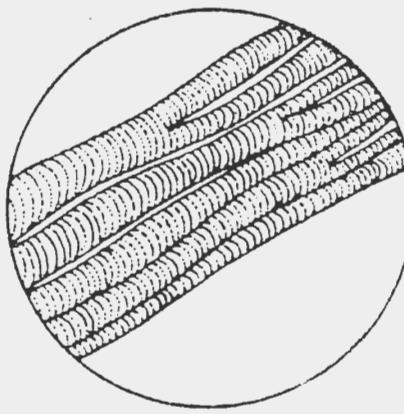
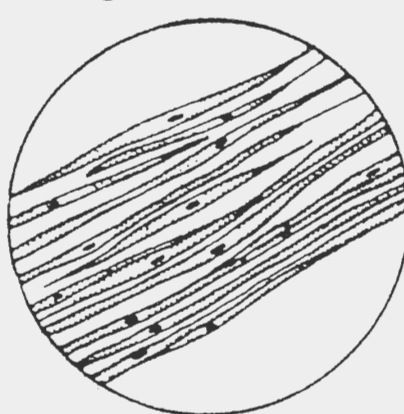
Epithelial tissue
(intestine lining)



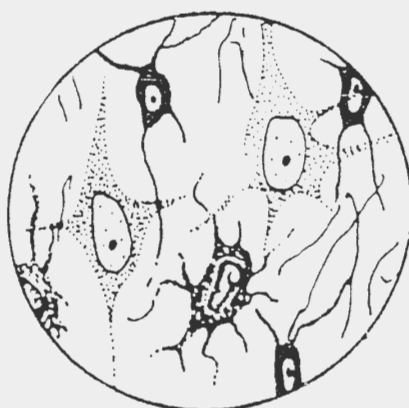
Connective tissue



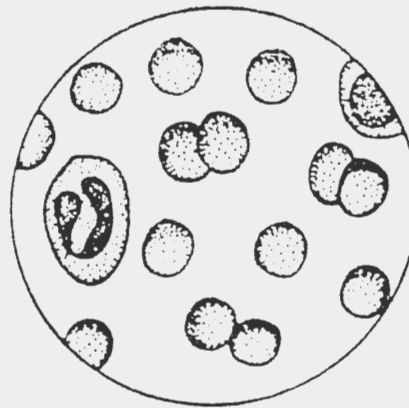
Connective tissue
(adipose)



Muscle tissue



Nerve tissue



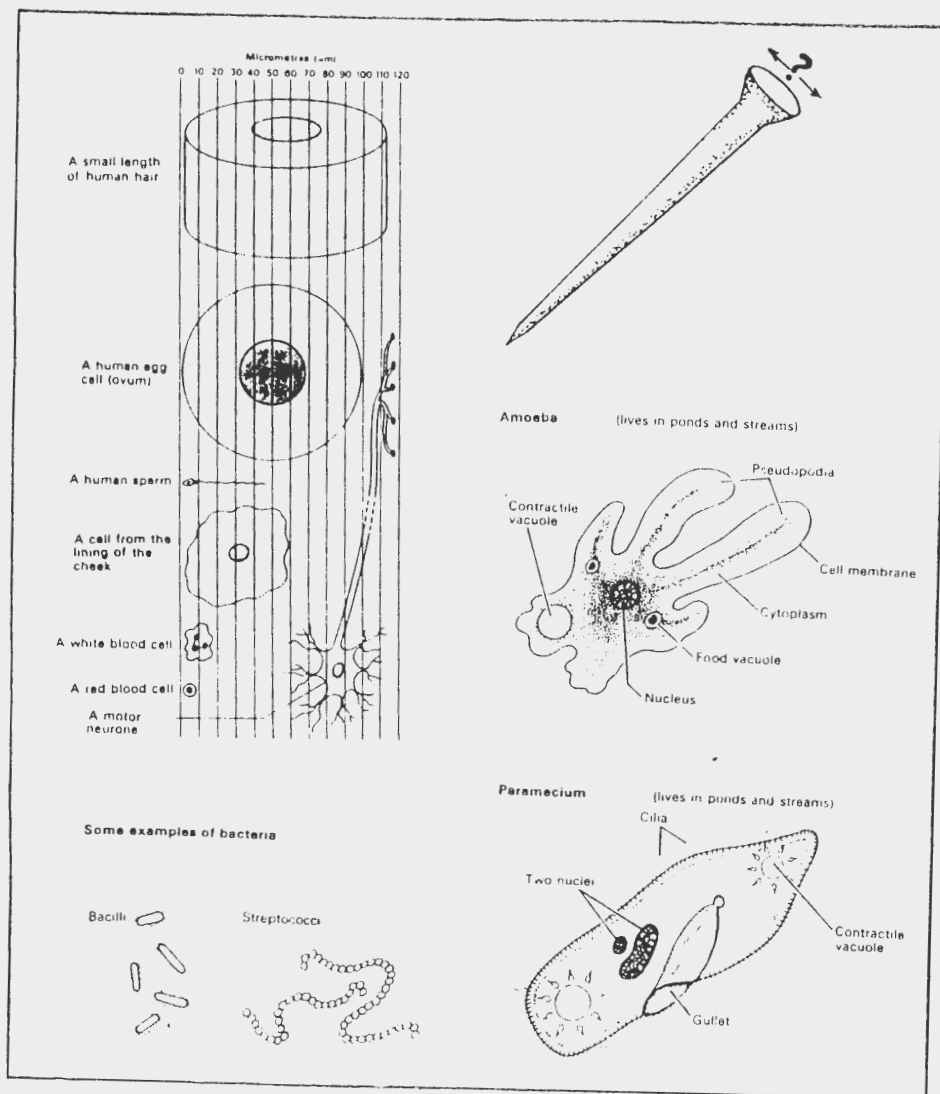
Blood tissue

An exercise on size

From the information provided on this page, answer the questions asked, and complete the table provided below.

Remember that $1\text{mm} = 1000\mu\text{m}$ and that the diameter of a pinhead = 1mm

NB: the diagrams below are not all drawn to scale



How many strands of hair would fit side-by-side across the diameter of the pinhead? Show your calculations.

Complete the following table, to show the size of each of the cells mentioned, and how many of each would fit next to each other across the head of a pin.

	diameter or length	no. across pinhead
bacteria streptococcus	$0,25\mu\text{m}$	
bacillus	$1\mu\text{m}$	
red blood cell		
white blood cell		
human sperm		
cell from cheek lining		
human egg cell		
Paramecium	$200\mu\text{m}$	
Amoeba	1mm	

Neurones (nerve cells) like the one shown need to be able to stretch from all parts of the body to the spinal cord, where they link with other nerve cells. This one could not fit on the page, so the artist has indicated, by means of broken lines, that the middle section has been removed. Human neurones (nerve cells) can be up to a metre in length!

- * Bacteria (germs) are one-celled organisms. Streptococcus and bacillus are terms used to describe two shapes of bacteria.
- * Paramecium and Amoeba are also one-celled organisms. They occur in pond water.

You will be learning more about all of these organisms in Std. 9.

- * You can see from this exercise that cells can vary tremendously in size.

Now look at your pin. Try and imagine the size of the different cells you have considered in this exercise.

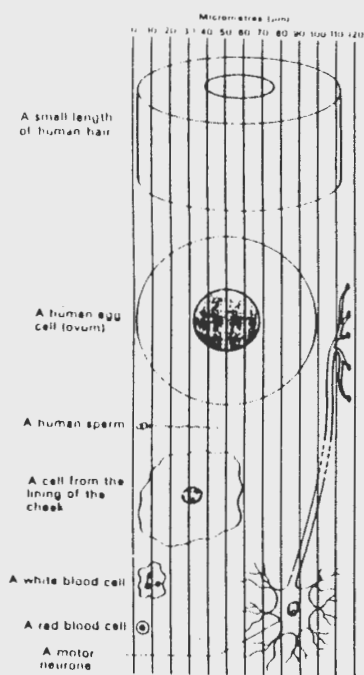
An exercise on size

Answers

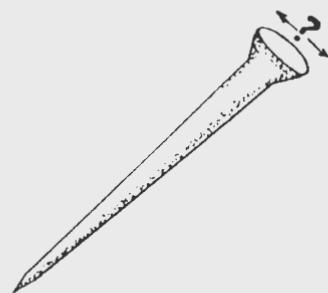
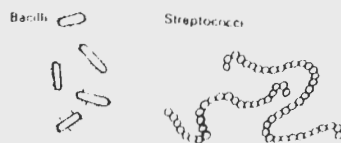
From the information provided on this page, answer the questions asked, and complete the table provided below.

Remember that $1\text{mm} = 1000\mu\text{m}$ and that the diameter of a pinhead = 1mm

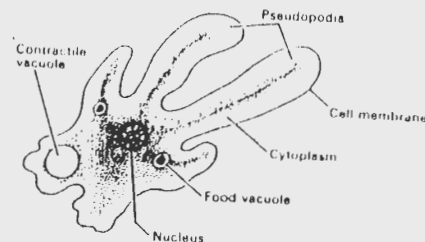
NB: the diagrams below are not all drawn to scale



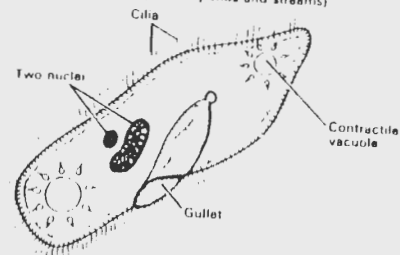
Some examples of bacteria



Amoeba (lives in ponds and streams)



Paramecium (lives in ponds and streams)



How many strands of hair would fit side-by-side across the diameter of the pinhead? Show your calculations.

Diameter of pinhead = $1\text{mm} = 1000\mu\text{m}$

Width of hair = $110\mu\text{m}$

$\therefore \frac{1000}{110} = 9$ hairs would fit onto pinhead

Complete the following table, to show the size of each of the cells mentioned, and how many of each would fit next to each other across the head of a pin.

	diameter or length	no. across pinhead
Bacteria streptococcus	$0,25\mu\text{m}$	4000
bacillus	$1\mu\text{m}$	1000
red blood cell	$\pm 8\mu\text{m}$	± 125
white blood cell	$\pm 15\mu\text{m}$	± 67
human sperm	$\pm 5\mu\text{m}$	± 200
cell from cheek lining	$\pm 60\mu\text{m}$	± 17
human egg cell	$\pm 100\mu\text{m}$	± 10
Paramecium	$200\mu\text{m}$	± 5
Amoeba	1mm	only 1

Neurones (nerve cells) like the one shown need to be able to stretch from all parts of the body to the spinal cord, where they link with other nerve cells. This one could not fit on the page, so the artist has indicated, by means of broken lines, that the middle section has been removed. Human neurones (nerve cells) can be up to a metre in length!

- * Bacteria (germs) are one-celled organisms. Streptococcus and bacillus are terms used to describe two shapes of bacteria.
- * Paramecium and Amoeba are also one-celled organisms. They occur in pond water.

You will be learning more about all of these organisms in Std. 9.

- * You can see from this exercise that cells can vary tremendously in size.

Now look at your pin. Try and imagine the size of the different cells you have considered in this exercise.

Teacher's comments on lesson

School: _____ Teacher: _____ Lesson No. _____

Time spent on lesson: _____

How lesson was taught: Please mention briefly how the lesson was dealt with e.g. teacher demonstration, whole class exercise, small group work, individual pupil work etc.

When exercises were done: Please mention (for each exercise) if these were done in class, or for homework.

Checking of answers: Please indicate whether the pupils' answers were checked, and if so, how this was done (e.g. answers displayed on a board, and pupils given 5 minutes at start of lesson to check their homework, or teacher went over answers in class at the end of the lesson etc.)

COMMENTS

Problems experienced by teacher:

Problems experienced by the pupils:

General comments on the lesson:

LESSON 5

(Revision of cell structure and function)

Recommended time

A single lesson

Purpose of lesson

1. To revise the basic structure of a typical plant and a typical animal cell (including names and functions of the cell organelles covered in Std 7) in such a way that the pupils see it as revision and not unnecessary repetition.
2. To emphasise the relative sizes of plant and animal cells, and the organelles they contain.

Requirements for lesson

1. Chalkboard.
2. Pupil exercises (1 per pupil)
 - looking at size (AGAIN!).

Points to make to the pupils

1. Explain that the purpose of the lesson is to revise the basic work they did in Std 7, on the structure of the cell.
2. Point out that in Std 8 they will be looking at cell structure in more detail, and that particular attention will be paid to accurate observation and drawing of the cell and its organelles, so that the drawings show the correct relative sizes of the structures.
3. It is suggested that you use an inquiry discussion with the whole class, to get the pupils to tell you what they remember (from Std 7) about the basic structure of the cell.
4. Start by drawing the outline of a plant cell on the chalkboard. Discuss the typical box-like shape of a plant cell. Briefly revise the related terms, and the function of the cell wall. Draw attention to the thickness of the cell wall relative to the size of the cell.

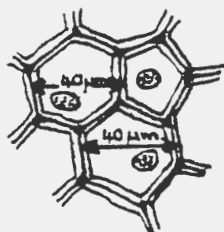
As you elicit the names of cell organelles from the pupils, get a pupil to come up and draw the organelle, and label it. Ask a second pupil to come up and annotate the diagram by adding the **function** of the organelle under discussion.

5. Ask the pupils to imagine the cell being lined by a large plastic bag, like a dustbin liner. Revise the terms associated with the cell membrane, its structure, and its function. Draw attention to the relative thinness of the membrane. Allow a pupil to draw the membrane on the board, and label it. Ask a second pupil to annotate it by adding its function.
6. Briefly revise the cytoplasm, in terms of names, structure and function. Discuss how the pressure of the cytoplasm pushes the cell membrane against the cell wall. Discuss the fact that animal cells do not have the counter-pressure of a containing cell wall. Allow pupils to add the necessary labels to the drawing.
7. Discuss the size and structure of the plant cell vacuole. Discuss the relative sizes and functions of the vacuoles in plant and animal cells. Try to elicit these facts from the pupils. Let them tell you, rather than you telling them. Allow the pupils to add the necessary details to the chalkboard diagram.
8. Discuss the shape, structure, and function of the nucleus. Point out that the vacuole in the plant cell pushes the nucleus to one side of the cell. Add the details to the drawing.
9. Now add the mitochondria (external view only). Discuss their shape and size relative to the cell. Note that they are quite small relative to the size of the nucleus and plastids.
10. Add the chloroplasts. Discuss only their external structure, and their size relative to the size of the cell. Briefly revise the function of the various plastids, as covered in Std 7.
11. Allow pupils to add the remaining cellular structures, with labels and annotations.
12. Now revise the basic differences between plant and animal cells. Start with the obvious one of the cell wall in plants. Then go on to the differences in the vacuoles, the centriole in animal cells, and the lack of plastids in animal cells. **Ask each pupil to draw up a tabular summary as the discussion proceeds.**
13. Give the pupils the exercise on size to start in class, so that you can help any pupils who might struggle with it. If they do not finish in class, the exercise must be completed for homework. Make sure that the answers are checked (either at the start of the next lesson, or by displaying them on the noticeboard, and asking that the pupils check their answers).

Thinking about size (AGAIN!)

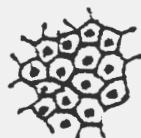
REVISION QUESTIONS:

1. How many of the cells shown here would fit side-by-side across a pinhead with a diameter of 1mm? (Show the steps in your calculation).



Imagine that you have to draw the pinhead to scale. Would you be able to fit it on this page? (Show your calculations for working out your answer.)

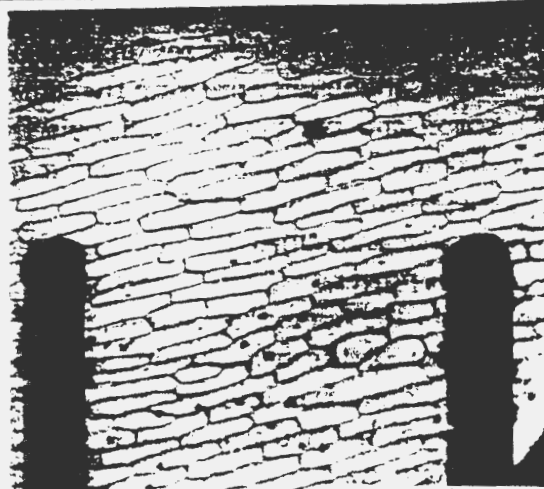
2. If the same cells were drawn 10 times smaller, using a scale of 1mm=10μm (as shown here), the pinhead would fit on the page. Using the information provided, calculate the size of the pinhead if drawn to this scale. Show all calculations.



Draw a dotted circle around the cells to represent the pinhead drawn to scale. (Your line may have to overlap some of the writing on this page).

3. This picture shows a piece of onion skin placed on a plastic ruler and viewed under an ordinary light microscope. The two black lines are two of the "millimetre" markings on the ruler. You can see that not all of the cells are exactly the same size.

Work out the average length of these onion epidermis cells. Show your calculations.



From: Living Biology - B (Kaske et al)

35: Next time you eat an onion, try and peel off a piece of the thin membrane found on around each layer of the onion. This is the onion epidermis. Try and imagine the cells which form it. If five could fit side by side across a pinhead, they are not really all that small!

4. Now try the exercise again, using this photograph of some moss leaf cells. Are they bigger or smaller than the onion epidermal cells?

Calculate the average size of these cells. Show your calculations.



From: Living Biology - 8 (Kaske et al)

You should now be a lot more familiar with the sizes of cells (after this exercise plus last week's lesson on size). It is obvious that cells vary tremendously in size!

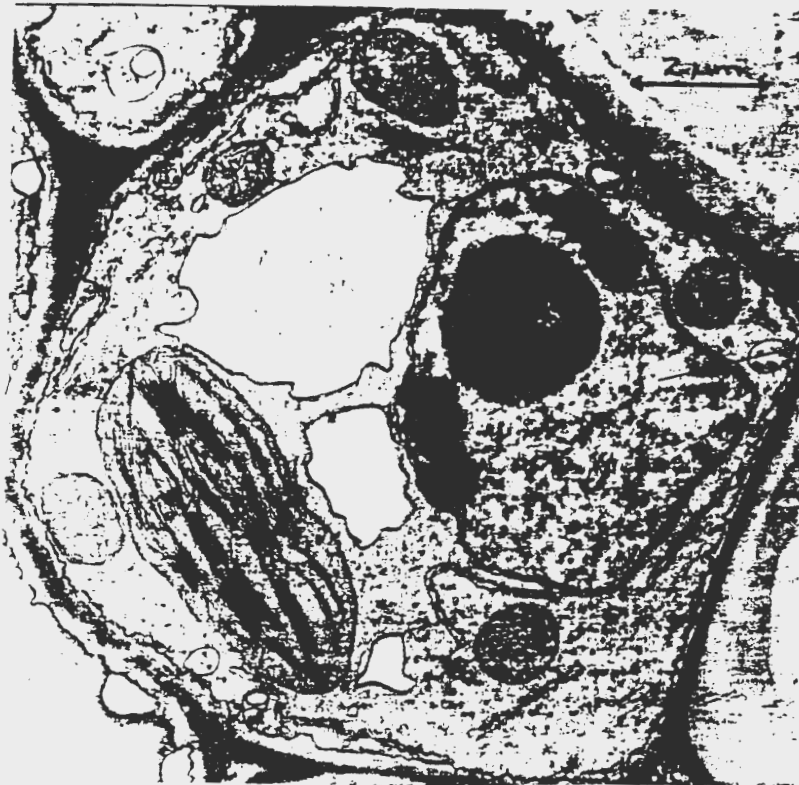
But what about the size of the organelles? In the same way that cells can vary in size, so can the organelles in them. These exercises should help you to get an idea of the sizes of organelles relative to the cells in which they occur.

1. The following table lists some plant cell organelles, together with some typical sizes, and the approximate number of each type of organelle found in a typical plant cell. The last column gives sizes of the cell which you are required to draw to scale.

Cell or organelle	no. per cell	typical size	size for drawing and no. to draw
cell (length)	-	-	35µm
thickness of wall	-	-	0.5µm
nucleus (diameter)	1	10-20µm	15µm (X 1)
chloroplast (length)	50-200	5-10µm	8µm (X 3)
mitochondrion (length)	500-2500	2-5µm	3µm (X 10)
golgi body (diameter)	1	-	4µm (X 1)

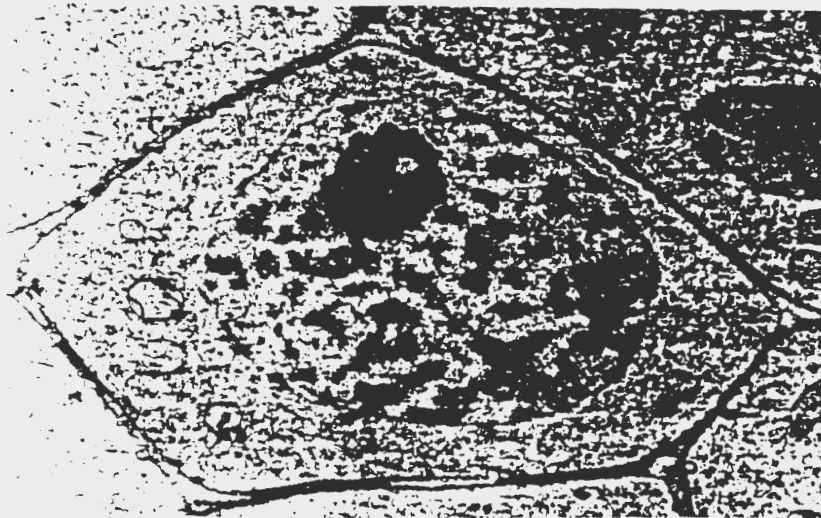
Using the measurements given in the last column, draw yourself a typical plant cell. Make it five-sided. Put in the number of organelles of each type shown in brackets in the last column of the table. Use a scale of 1mm = 1µm.

2. To show you how size can vary, answer the following questions, using this photograph of a cell from a clover plant.
- What is the actual length of the chloroplast in μm ?
 - What is the actual diameter of the nucleus in μm ?
 - What is the length of the longest mitochondrion (in μm)?
 - How thick is the cell wall in μm ? NB: measure the wall of one cell, not the walls of two adjoining cells.
 - What is the length of the largest vacuole?

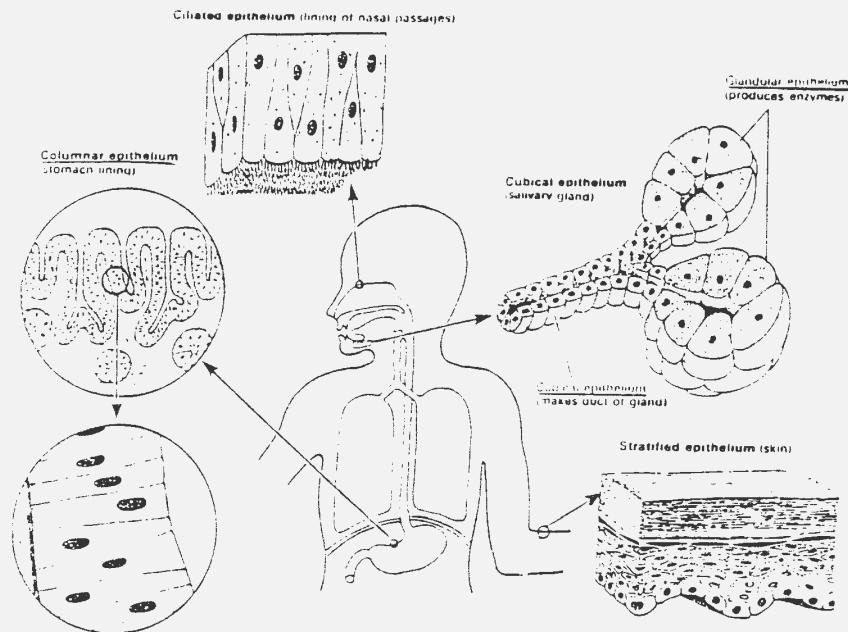


From: The cell (SACHED, 1981)

Now look at this plant cell, from the growing shoot of wheat. Look at the size of the nucleus relative to the cell.



3. This diagram shows some of the types of epithelial tissues found in the human body. Remember that a tissue is made up of a group of cells with a similar structure and function.



Let us look at one columnar epithelial cell from the stomach lining, one cuboidal epithelial cell from the duct of the salivary gland, and one glandular epithelial cell from the salivary gland itself. To simplify matters, the largest cell of each type (in the drawing) has been copied into the blocks below.

For each cell type, work out approximately how many nuclei from that cell could fit across the diameter of the cell. Fill in the answers on the dotted lines below the drawings.

columnar
epithelial cell



cuboidal
epithelial cell



glandular
epithelial cell

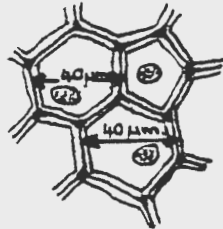


So you can see that the size of the nucleus relative to the size of the cell can differ quite substantially!

Thinking about size (AGAIN!)

Measurements given in this answer sheet reflect sizes on the original worksheets. All teaching materials included in this Volume have been reduced to 85% of original size to fit them onto the pages.

1. How many of the cells shown here would fit side-by-side across a pinhead with a diameter of 1mm? (Show the steps in your calculation).



Diameter of pinhead = 1mm
= 1000μm
If cell is 40μm across
You would fit $\frac{1000}{40} = 25$ across the pinhead

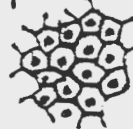
Imagine that you have to draw the pinhead to scale. Would you be able to fit it on this page? (Show your calculations for working out your answer.)

Measure the cells: 40μm is 1.5cm on this page
∴ 10μm is 0.4cm
∴ 1000μm is 40cm

The pinhead would have to be 40cm across.

The page is only 21cm wide - too small to draw the pinhead to scale.

2. If the same cells were drawn 10 times smaller, using a scale of 1mm=10μm (as shown here), the pinhead would fit on the page. Using the information provided, calculate the size of the pinhead if drawn to this scale. Show all calculations.



1mm = 10μm
∴ 1000μm (size of pin) = 100mm.

approximate size of pinhead. ←

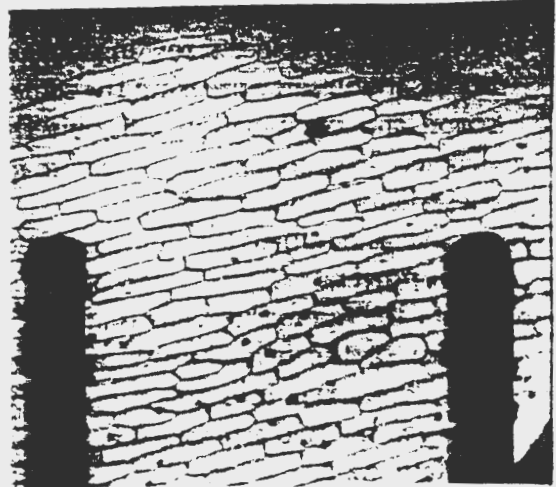
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3. This picture shows a piece of onion skin placed on a plastic ruler and viewed under an ordinary light microscope. The two black lines are two of the "millimetre" markings on the ruler. You can see that not all of the cells are exactly the same size.

Work out the average length of these onion epidermis cells. Show your calculations.

About 4 cells fit (lengthwise) between the 1mm markings
∴ 1 cell = $\frac{1\text{mm}}{4}$ (or 1000μm)

∴ Average length of onion cell = 250μm



From: Living Biology - 8 (Kaske et al)

NB: Next time you eat an onion, try and pull off a piece of the thin membrane found on around each layer of the onion. This is the onion epidermis. Try and imagine the cells which form it. If five could fit side by side across a pinhead, they are not really all that small!

4. Now try the exercise again, using this photograph of some moss leaf cells. Are they bigger or smaller than the onion epidermal cells?

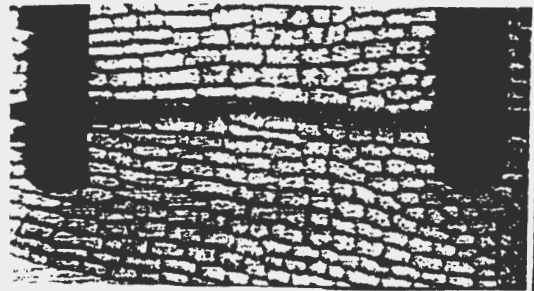
Smaller

Calculate the average size of these cells. Show your calculations.

About 12 fit into 1mm (1000µm)

∴ average length of 1 cell

= ± 83µm



From: Living Biology - 8 (Kaske et al)

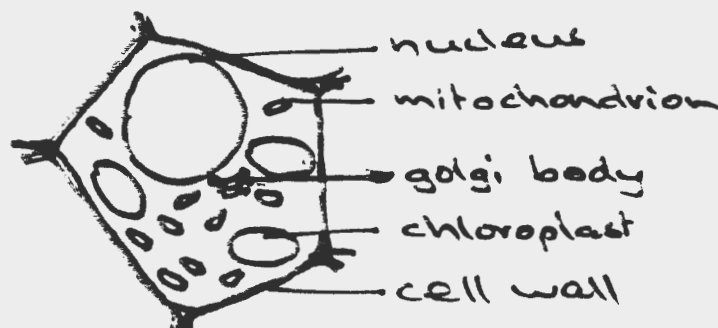
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golgi body (diameter)	1	-	4µm (X 1)

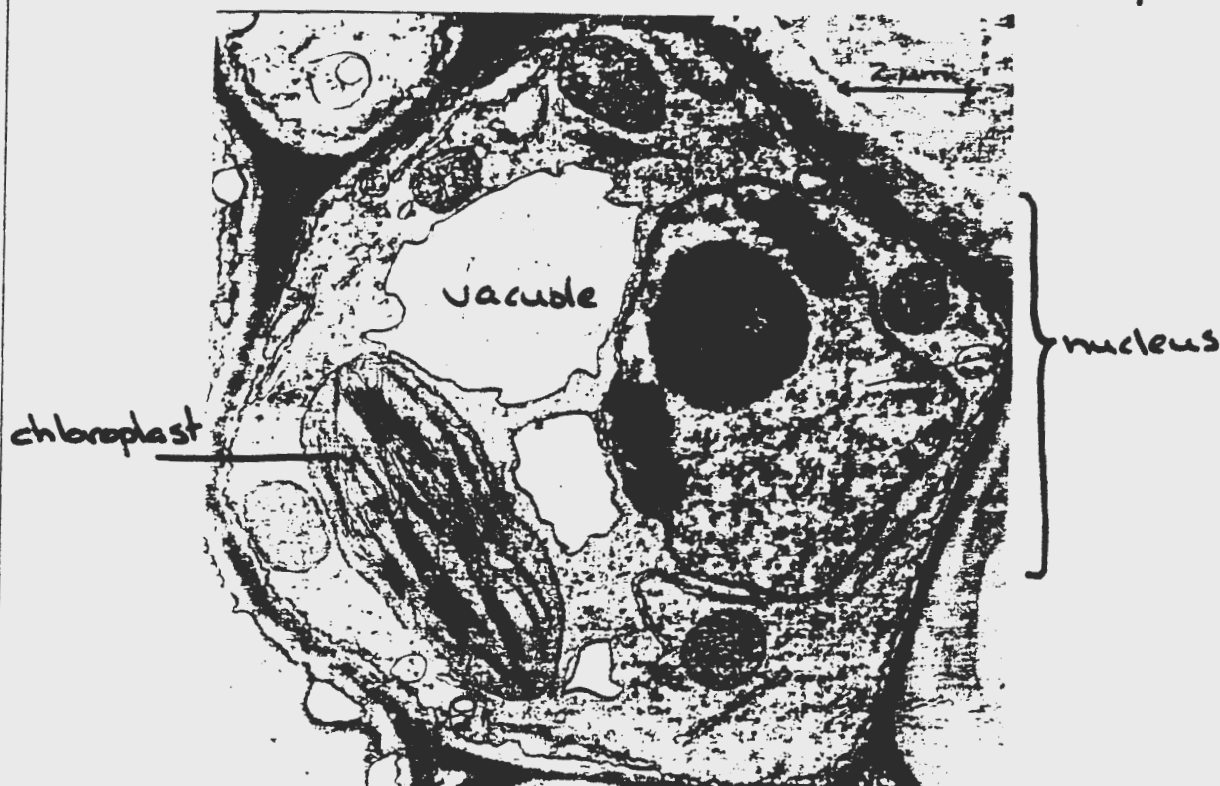
Using the measurements given in the last column, draw yourself a typical plant cell. Make it five-sided. Put in the number of organelles of each type shown in brackets in the last column of the table. Use a scale of 1mm = 1µm.



2. To show you how size can vary, answer the following questions, using this photograph of a cell from a clover plant.

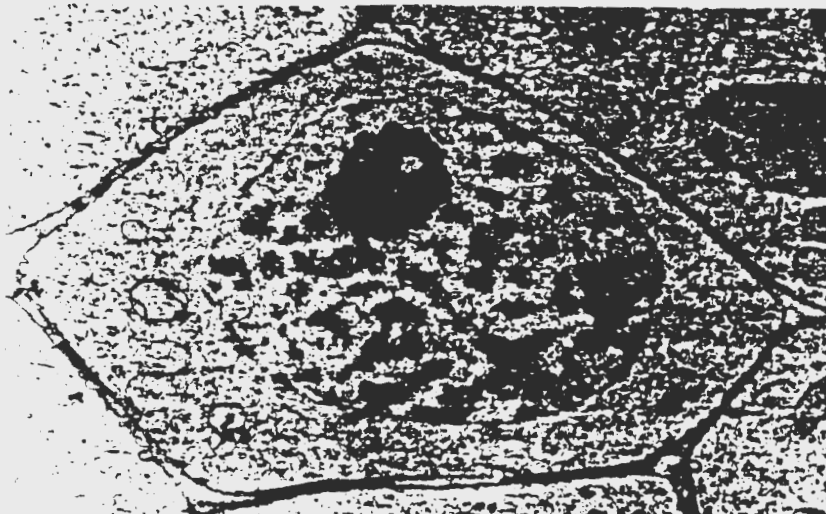
$2\mu\text{m} = 2\text{mm}$ (on this page) $1\text{cm} = 1\mu\text{m}$

- What is the actual length of the chloroplast in μm ? $6\text{cm} = 6\mu\text{m}$
- What is the actual diameter of the nucleus in μm ? $\pm 5-6\text{cm} = \pm 5-6\mu\text{m}$
- What is the length of the longest mitochondrion (in μm)? $2\text{cm} = 2\mu\text{m}$
- How thick is the cell wall in μm ? NB: measure the wall of one cell, not the walls of two adjoining cells. $2\text{mm} = 0,2\mu\text{m}$
- What is the length of the largest vacuole? $\pm 4,5\text{mm} = \pm 4,5\mu\text{m}$



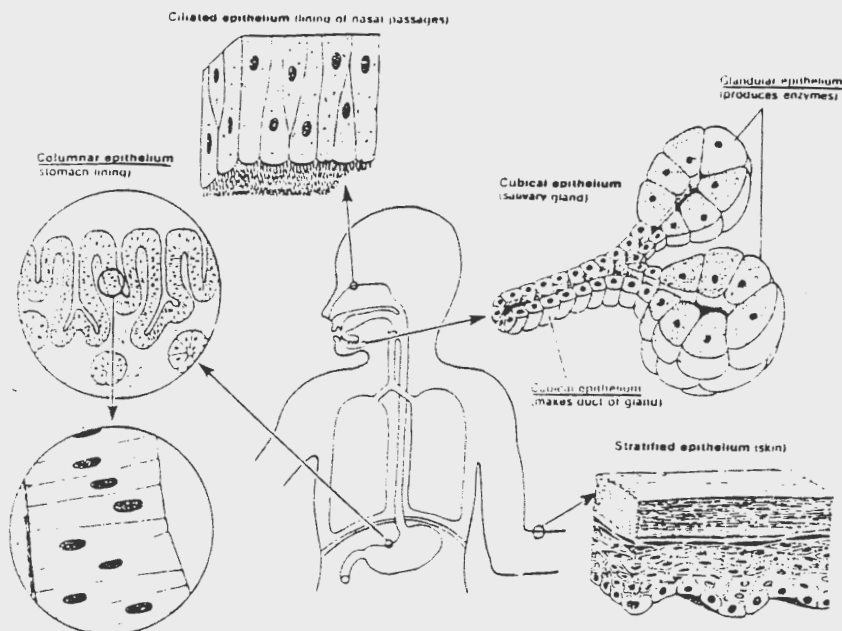
From: The cell (SACHED, 1981)

Now look at this plant cell, from the growing shoot of wheat. Look at the size of the nucleus relative to the cell.



nucleus almost
fills cell

3. This diagram shows some of the types of epithelial tissues found in the human body. Remember that a tissue is made up of a group of cells with a similar structure and function.



Let us look at one columnar epithelial cell from the stomach lining, one cuboidal epithelial cell from the duct of the salivary gland, and one glandular epithelial cell from the salivary gland itself. To simplify matters, the largest cell of each type (in the drawing) has been copied into the blocks below, *enlarged proportionally*.

For each cell type, work out approximately how many nuclei from that cell could fit across the diameter of the cell. Fill in the answers on the dotted lines below the drawings.

columnar
epithelial cell



cell = 8mm diameter
nucleus = 4mm wide
 $\therefore 8/4 = 2$ would fit

cuboidal
epithelial cell



cell = 4mm diam.
nucleus = 3mm wide
 $4/3 = \text{only } 1\frac{1}{3}$ would fit

glandular
epithelial cell



cell = \pm 1cm diam
nucleus = 2mm wide
 $10/2 = 5$ would fit

So you can see that the size of the nucleus relative to the size of the cell can differ quite substantially!

Teacher's comments on lesson

School: _____ Teacher: _____ Lesson No. _____

Time spent on lesson: _____

How lesson was taught: Please mention briefly how the lesson was dealt with e.g. teacher demonstration, whole class exercise, small group work, individual pupil work etc.

When exercises were done: Please mention (for each exercise) if these were done in class, or for homework.

Checking of answers: Please indicate whether the pupils' answers were checked, and if so, how this was done (e.g. answers displayed on a board, and pupils given 5 minutes at start of lesson to check their homework, or teacher went over answers in class at the end of the lesson etc.)

COMMENTS

Problems experienced by teacher:

Problems experienced by the pupils:

General comments on the lesson:

FURTHER LESSONS

The structure and function of cells

Teachers should proceed with these lessons in the normal way. However, they are asked to give the pupils the worksheets on cell organelles to complete. The pupils should also be asked to complete several practice exercises involving observation and drawing.

Worksheets

The pupils should be given the appropriate worksheet as they complete the work on each organelle. They should be encouraged to complete the worksheets at school, when time permits. Otherwise they can be completed for homework.

Drawing exercises

Teachers are asked to constantly remind the pupils of the importance of accurate observation and drawing. Set the pupils a short drawing exercise at least twice a week, whilst they do the work on the cell. These drawing exercises should not involve merely copying from the textbook, but getting pupils to draw from micrographs (either photographs, 35mm slides, or overhead transparencies).

FURTHER LESSONS

The structure and function of cells

Teachers should be encouraged with their students to the extent that they are able to plan the pupils' activities in order to complete the work. The pupils should be able to complete several practical exercises involving observation and drawing.

Workbooks

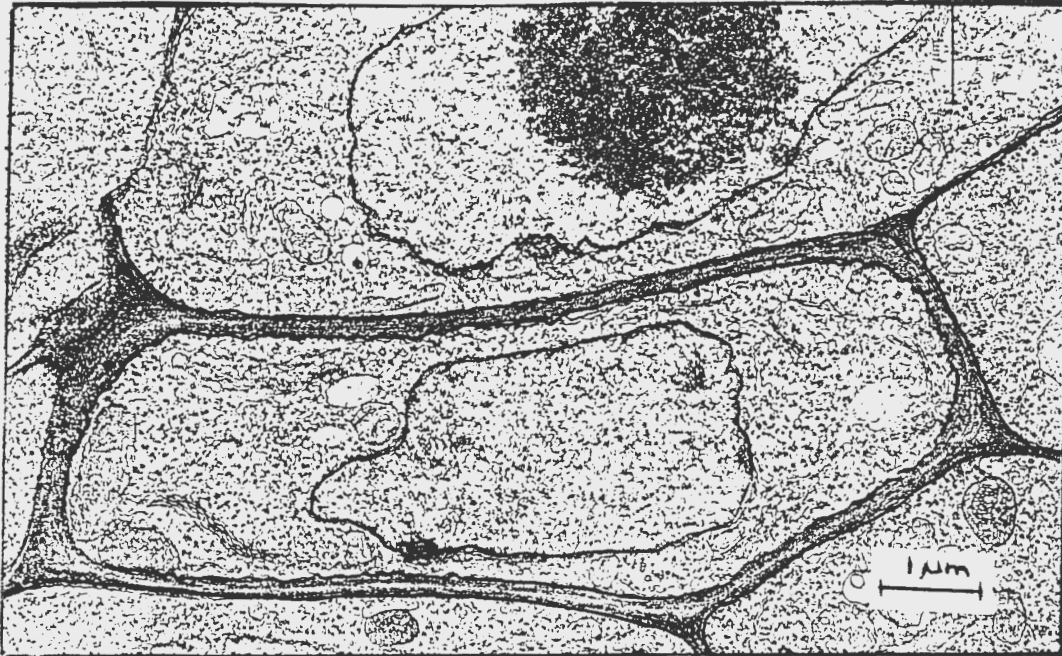
The workbooks should be used as a guide to the work. The pupils should be encouraged to complete the work in their own time. The workbooks should be used as a guide to the work.

Using the microscope

The pupils should be encouraged to use the microscope to observe the structure and function of cells. The pupils should be encouraged to draw the structures they observe. The pupils should be encouraged to complete the work in their own time. The workbooks should be used as a guide to the work.

CELL WALLS AND CELL MEMBRANES

- 1a) In this electron micrograph of some cells from the root tip of a bean, the cell wall of the lower cell is particularly clear. Use the scale provided to estimate the average thickness of the cell wall in μm . Show your calculations.



- 1b) The plasmalemma (cell membrane) is also clearly visible. Label the cell wall and the plasmalemma on your diagram.

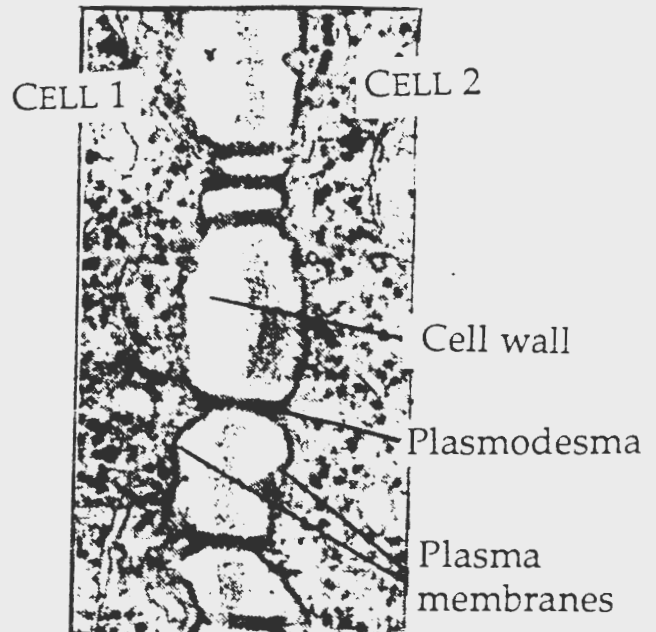
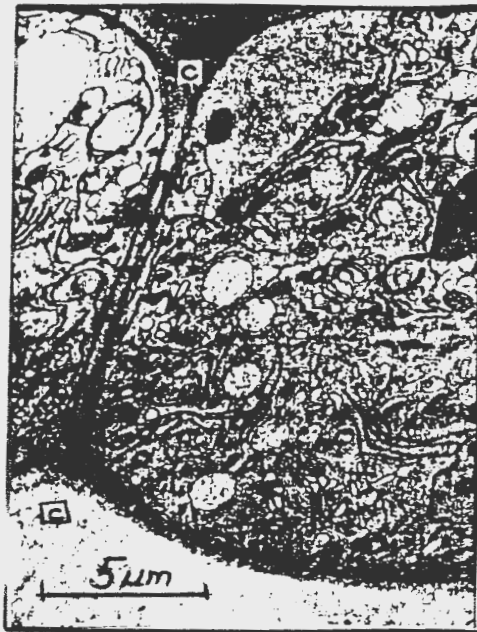
- 2a) Carefully examine the electron micrograph shown below, and decide if it shows plant or animal cells. List THREE reasons (visible in the micrograph) for your answer.

1. _____
2. _____
3. _____



- 2b) Use the scale provided to estimate the thickness of the cell wall (in μm). Show how you got your answer. _____ μm

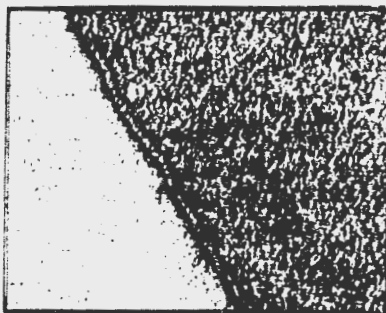
3. The electron micrograph on the left shows plasmodesmata, which are visible as black lines across the part of the cell wall labelled C--C. You will have to look carefully as the picture is very dark.



The electron micrograph on the right (above) shows a group of plasmodesmata, highly magnified. See if you can find them.

What is a plasmodesma (plural = plasmodesmata)?

4. These electron micrographs are extremely highly magnified, far beyond any of the electron micrograph pictures you would normally see. They show a single cell membrane (called the unit membrane).



Part of a human red blood cell.

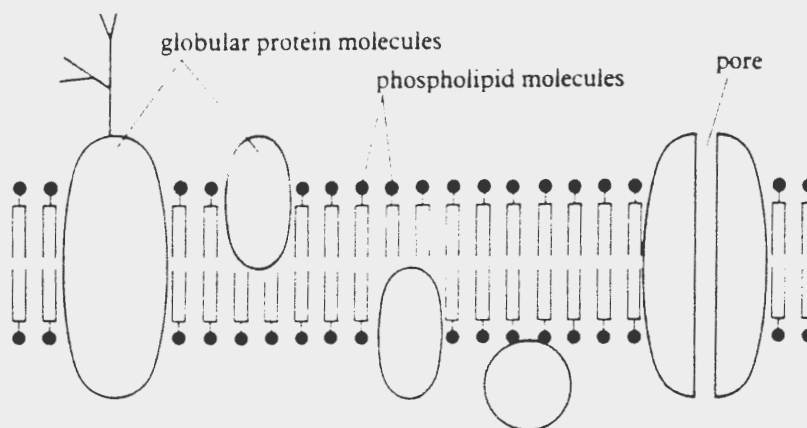


Part of a toad egg.

They show that the single membrane appears to be made up of three layers – a light inner layer sandwiched between two dark outer layers.

When biologists first saw this, they conducted experiments to find out more about the layers. They worked out that the cell membrane contained phospho-lipids and proteins, and they decided that the outer (darker) zones were layers of protein, and the inner (light) zone was made up of TWO layers of phospholipid molecules.

The following diagram shows a more recent interpretation of the structure of the membrane.



Locate the double (inner) layer of phospholipid molecules. Now locate the proteins. Notice how they do not form a solid layer on each side of the phospholipid layer, but rather they are embedded in it. They are able to shift around in the lipid layer, rather like life-buoys floating in a sea of treacly phospholipids.

5. Carefully examine the following electron micrograph. How many cell membranes can you see?



Would you say that this is the outer membrane of a single animal cell, or the cell membranes of two adjoining cells?

Justify (explain) your answer.

6. Briefly state the functions of

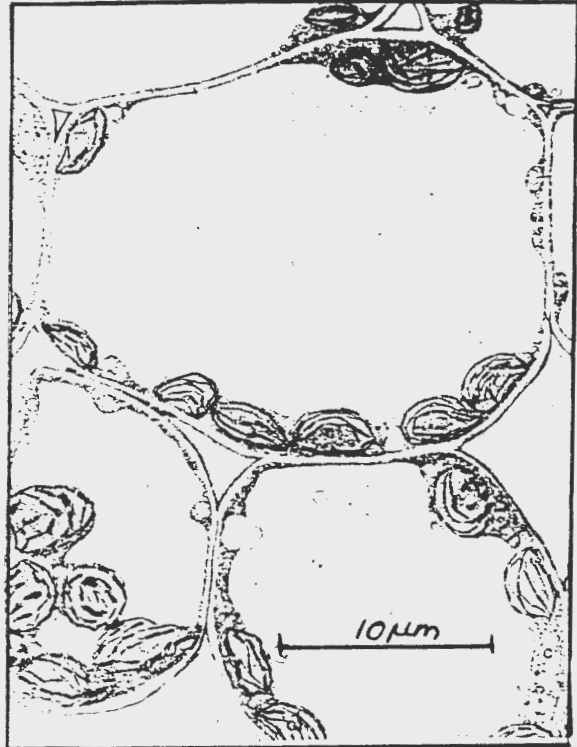
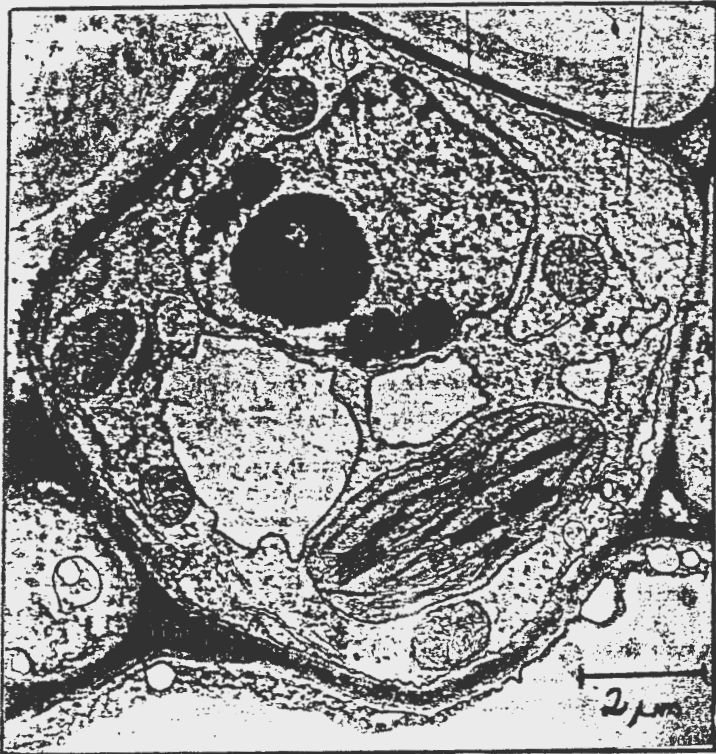
- a) Cell walls
- b) Plasmodesmata
- c) The cell membrane (plasmalemma)

VACUOLES

1a) Label the **vacuole** and the **tonoplast** in each of the following micrographs.

picture 1

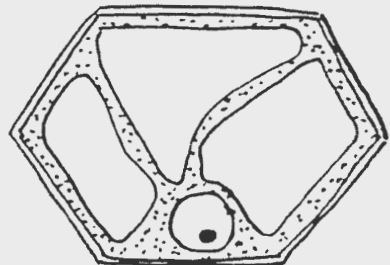
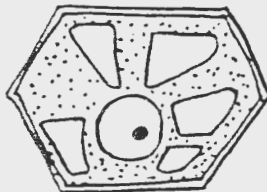
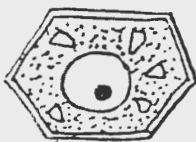
picture 2



1b) Use the scale provided in each photograph to measure the length of the largest vacuole in each cell. Indicate the length on the photograph in each case.

1c) How many vacuoles are there per cell, in picture 1 _____ and in picture 2 _____ ?

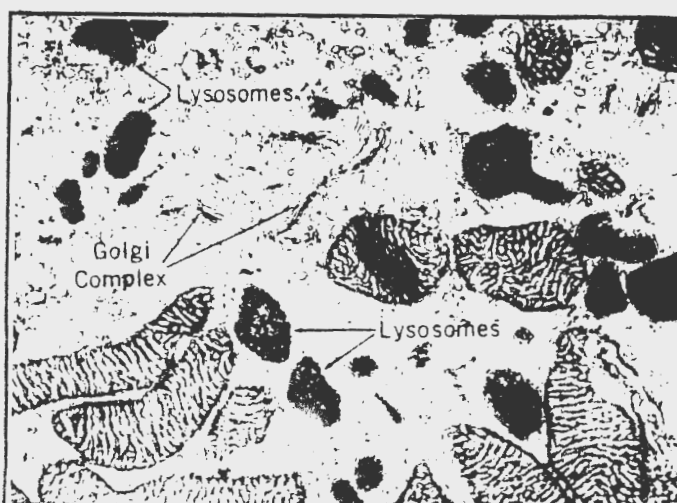
1d) Use the following sketches to try to work out what happens to a plant cell as it matures. Explain your theory.



2a) How do the vacuoles in a plant cell differ from those in animal cell?

2b) The vacuoles of animal cells are usually called vesicles. They often form by being pinched off from the membrane of other structures. Name TWO structures in the cell where the membrane pinches off to form vesicles or vacuoles. _____

2c) The vesicle often encloses digestive enzymes, and becomes a lysosome. Locate the lysosomes in the electron-micrograph below. Use the scale provided to estimate the size of the medium-sized lysosomes shown. _____ μm .



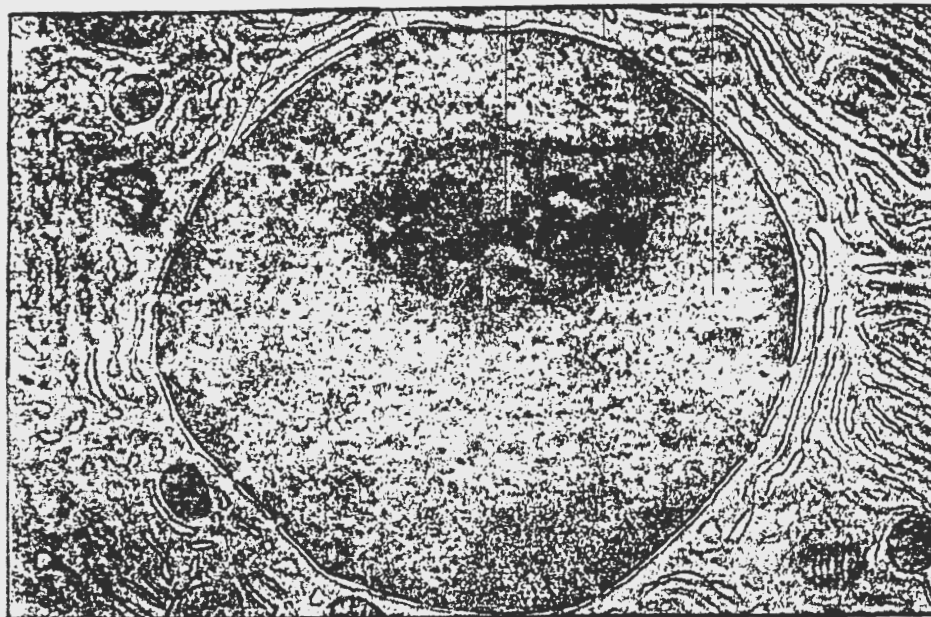
3. Briefly state the functions of vacuoles

a) In plant cells

b) In animal cells

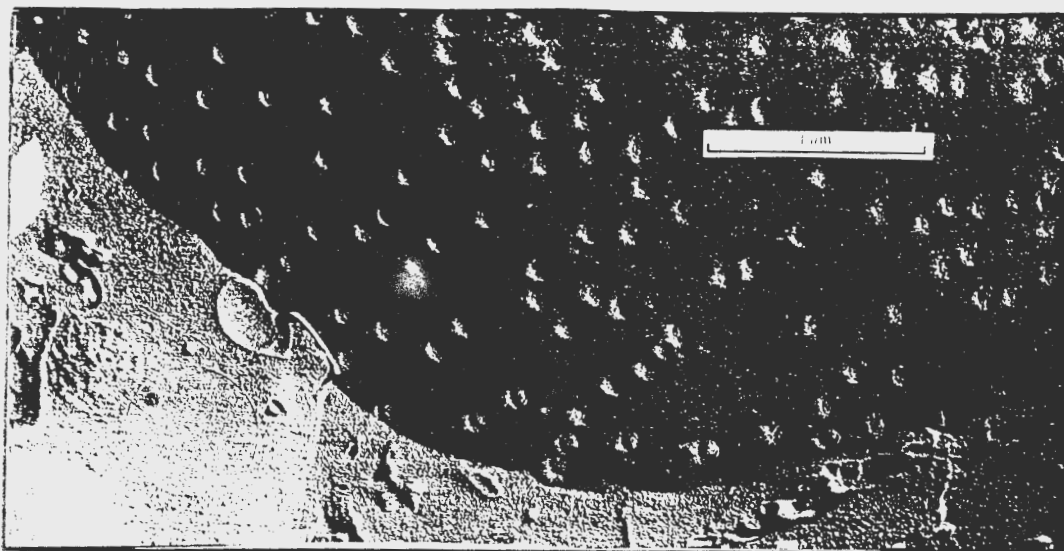
THE NUCLEUS

- 1a) This electron-micrograph shows a close-up view of a nucleus. Locate and label the **double nuclear membrane**, **nuclear pores**, **nucleolus**, and the **chromatin material**.



- 1b) Use the scale provided to work out the diameter of the nucleus (_____ μm) and the length of the rather irregularly shaped nucleolus (_____ μm).

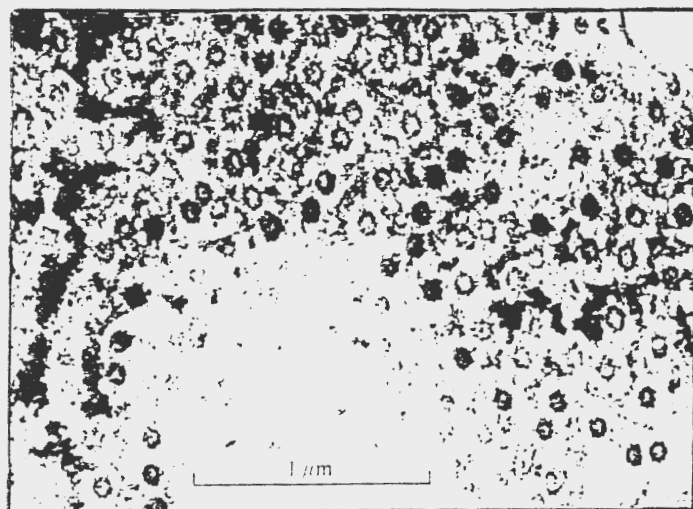
2. This amazing surface view of a nucleus was produced by a technique called freeze-etching.



The living specimen is quickly frozen to a temperature of about -100°C . A razor blade or the blade of a microtome (cutting machine) is then used to split or fracture the specimen along its lines of weakness. A mould is then made of the structure, using carbon. This, in turn, is used to produce a platinum replica of the original, which can then be viewed using a scanning electron microscope.

What are the circular holes shown in the micrograph? _____

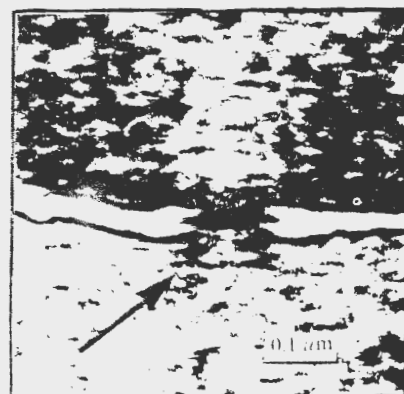
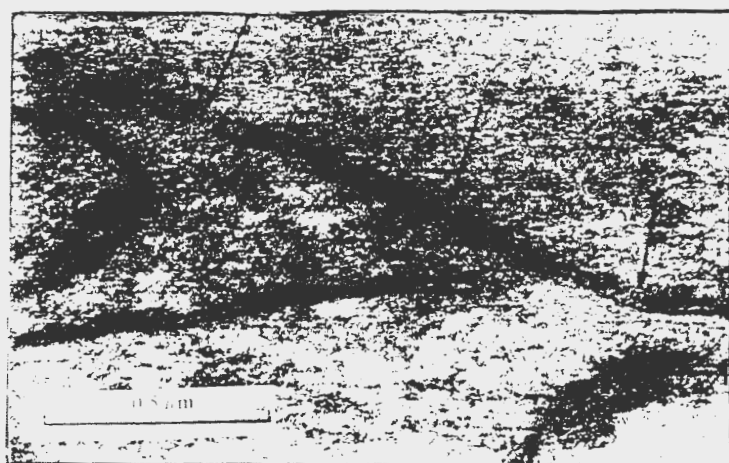
3. This electron micrograph also shows the surface view of a nuclear membrane, with the nuclear pores clearly visible.



- 3a) Use the scale provided to estimate how many pores, if placed side-by-side, would fit into 1 μm.

- 3b) Now work out the average diameter of the nuclear pores shown. Show your calculations.

4. This close-up of the nuclear envelope clearly shows the double nature of the membrane, and the structure of several nuclear pores.



Biologists have found that in the nuclei of some cells, a membrane is stretched across the pores, probably to control the passage of certain substances into or out of the nucleus.

Carefully examine the two micrographs above. Which one (left or right) shows such membranes across the pores? _____

5. Briefly explain the functions of

a) the nucleus

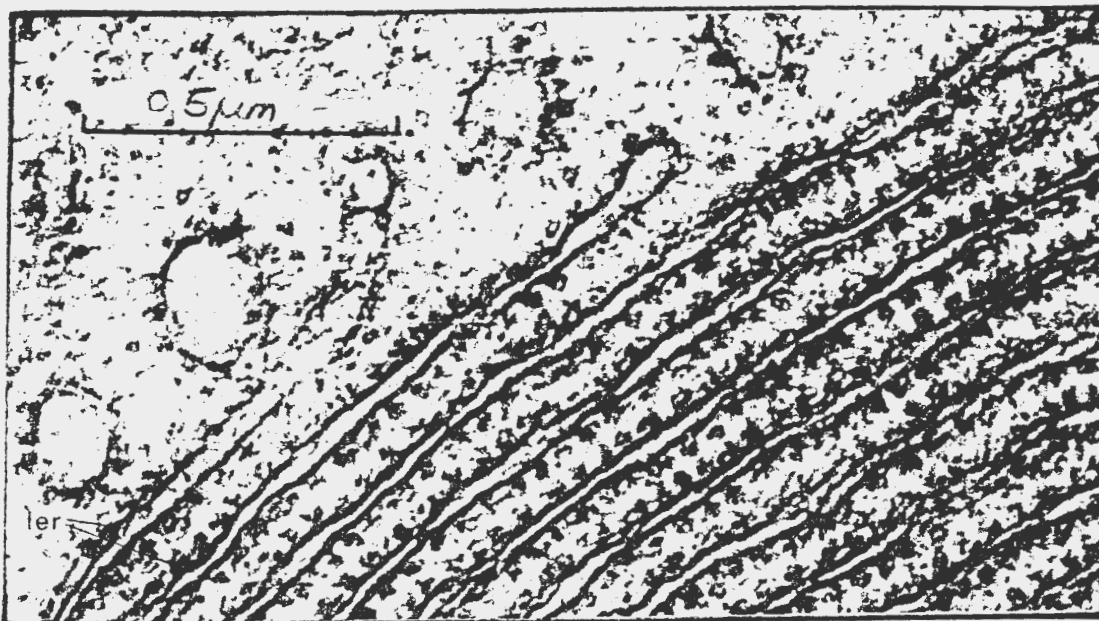
b) the nuclear pores

c) the chromatin material

d) the nucleolus

ENDOPLASMIC RETICULUM

- 1a) Carefully examine the rough endoplasmic reticulum shown in the following micrograph. Label the **endoplasmic reticulum** and the **ribosomes** which give it the name of "rough" ER.



- 1b) Are the ribosomes on the inside or the outside of the endoplasmic reticulum?
- _____

2. Briefly state the functions of

a) smooth endoplasmic reticulum

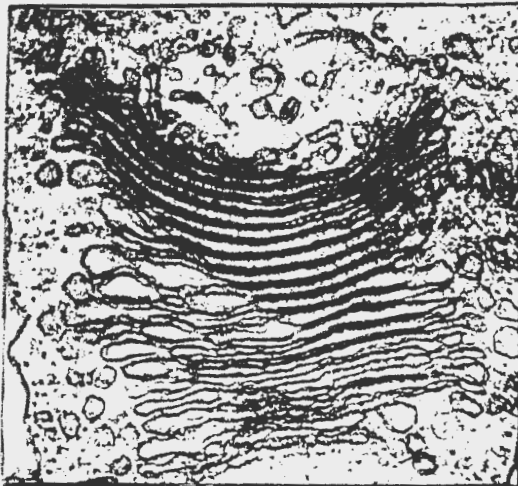
b) rough endoplasmic reticulum

THE GOLGI APPARATUS

- 1a) Carefully examine the following electron micrograph. Label the following structures:- **cisternae**, **vesicle**, **dictyosome**.



- 1b) Use the scale provided to estimate the width and height of the golgi body in the cell on the upper left.
width _____ height _____
- 1c) Approximately how many cells can you see in this golgi body? _____
- 1d) How many vesicles are there in the following golgi apparatus? _____

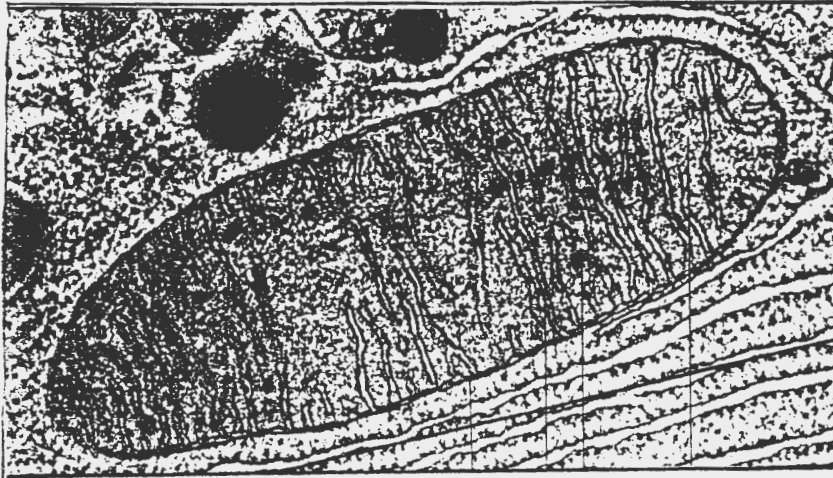


Thus you can see that the structure of the golgi body varies widely.

2. Briefly state the function(s) of the golgi body.

MITOCHONDRIA

- 1a) Carefully examine the following electron micrograph of a mitochondrion, and then label the following structures. **cisternae**, **matrix**, **inner membrane**, and **outer membrane**.



- 1b) Use the scale provided to estimate the length and the width of the mitochondrion.
length _____ width _____

Explain how you worked out your answers.

2. In what ways are mitochondria similar to chloroplasts, and how do they differ from them?

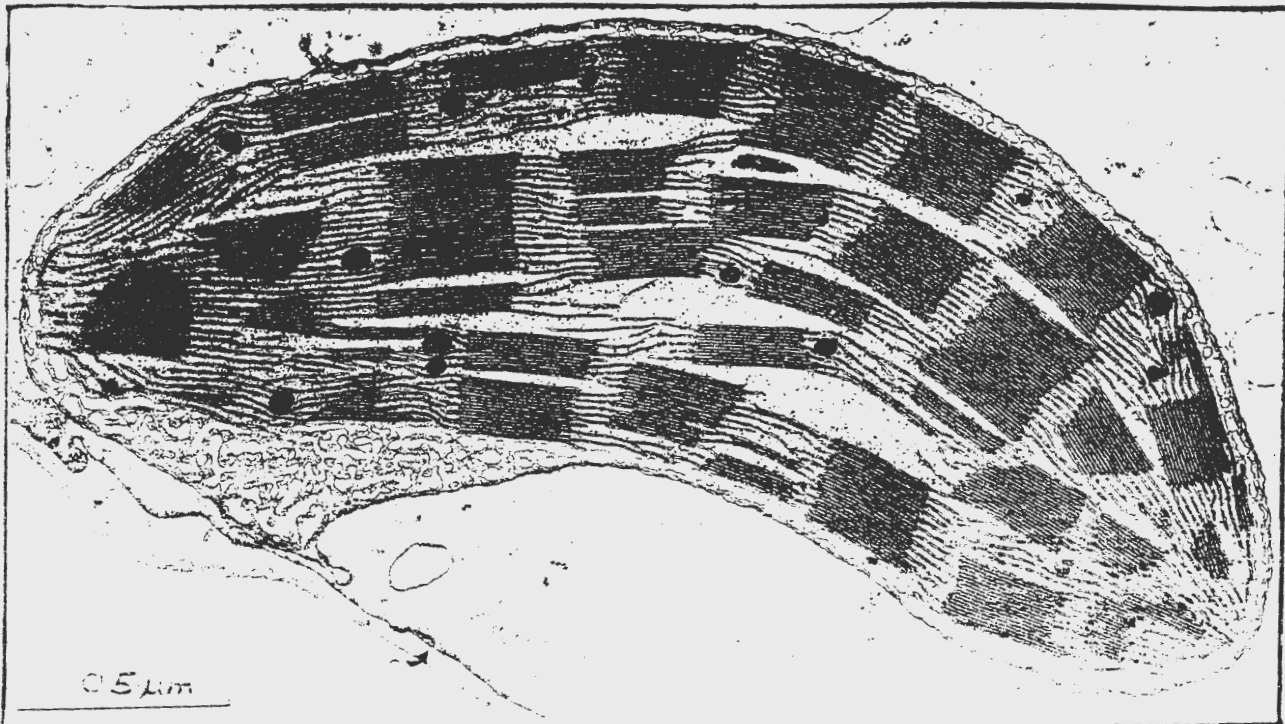
Similarities

Differences

3. Briefly state the function of mitochondria.

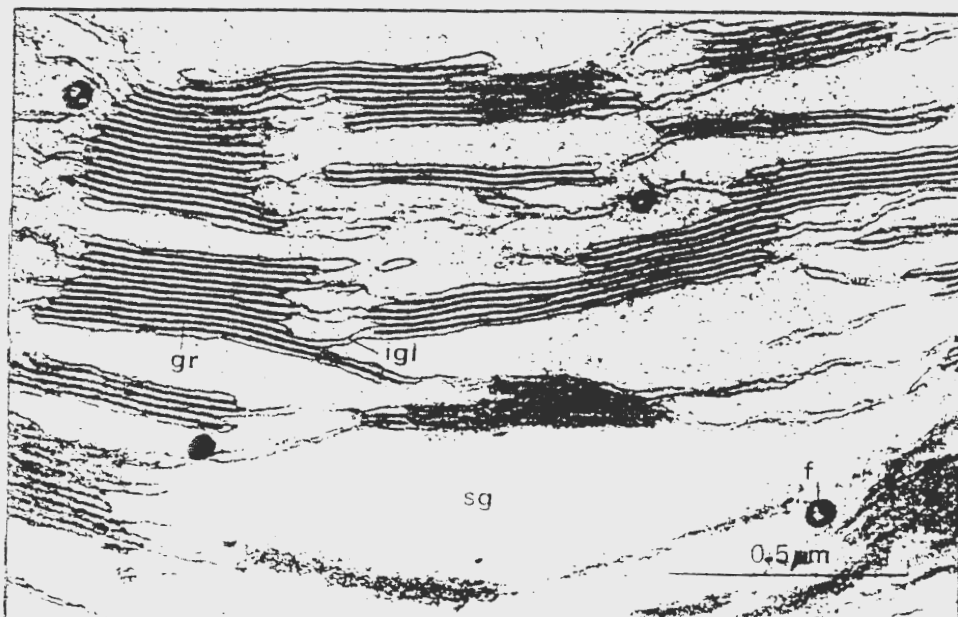
CHLOROPLASTS

- 1a) Carefully examine the following electron micrograph of a chloroplast. Label the following structures:-
inner membrane, outer membrane, stroma, granum, thylakoid, inter-granal lamella.

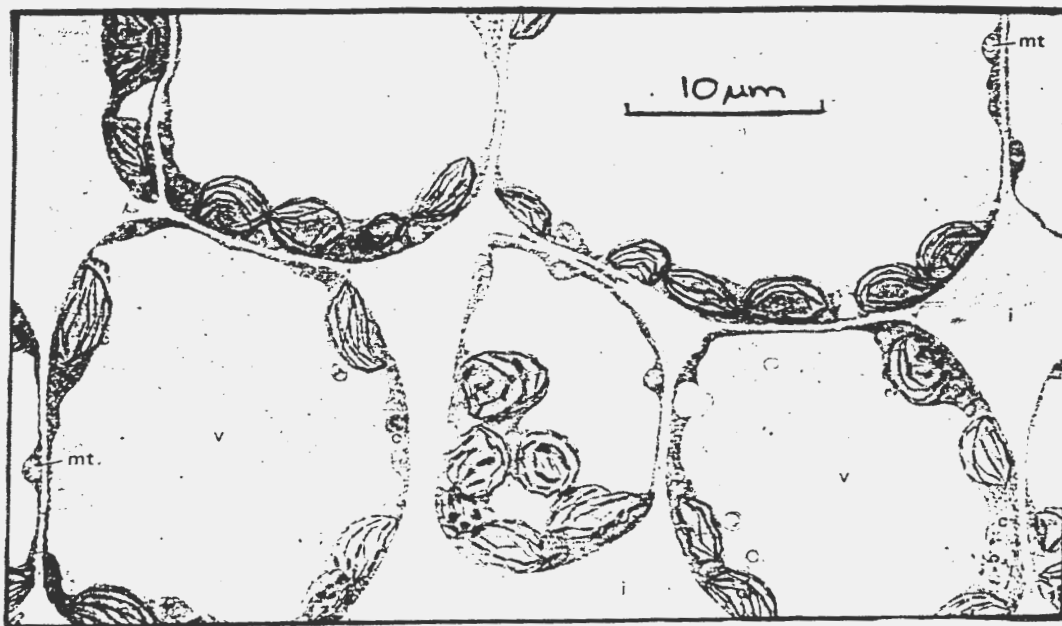


- 1b) Use the scale provided to work out the length and the width of this chloroplast.
length _____ width _____

The following micrograph shows a close-up of the chloroplast. Identify the thylakoid, stroma, granum, and inter-granal lamellae.



2. This electron-micrograph gives you a good idea of the size of chloroplasts relative to the spinach leaves in which they occur.



- 2a) Label a chloroplast in your picture.
- 2b) Why does the cell appear almost empty, with the chloroplasts squashed against the cell wall?

- 2c) Use the scale provided to estimate the length of the largest chloroplast you can see.
_____ μm. Now work out the length of the cell it is in. _____ μm.

3. Briefly state the functions of
a) chloroplasts

- b) the other types of plastids you have learned about.

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